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EXPERIMENTAL STUDIES ON TWO FISH TREMATODES OF THE GENUS HAMACREADIUM *(FAMILY ALLOCREADIIDAE)**

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INTRODUCTION

The life history of *Hamacreadium mutabile* Linton 1910, a trematode parasitic in the gray snapper at Tortugas, Florida, has recently been reported by the writer (McCoy, 1929). The cercariae which are of the cotylocercous type were obtained from the marine snail, *Astraea americana,* and were found to encyst in the tissues of various small fish. Fish experimentally infested with the cysts were fed to the gray snapper, *Lutianus griseus,* and the adult worms developed in the intestine and pyloric ceca of the fish. These studies were continued during the summer of 1929 and the life history of a second species of Hamacreadium, *H. gulella* Linton 1910, also parasitic in the gray snapper, has been worked out (McCoy, 1929a).

Since large numbers of the cercariae could be obtained from naturally infested snails, the life cycles of *H. mutabile* and *H. gulella* could readily be completed in the laboratory and it was possible to study experimental infections with quantitative methods. There is very little quantitative information regarding the course of infection of trematodes in their hosts. The life cycles are usually so incompletely known and difficult to carry out experimentally that there are only a few forms with which such studies could be attempted. The life cycles of the two species of Hamacreadium are suitable for experimental work because the cercariae can readily be obtained in large numbers, the infections administered quantitatively, and the fish hosts easily handled and kept alive in the laboratory. The material is also unique in that the definitive host is a fish. The present paper contains an account of the life history of *Hamacreadium gulella,* and the results of some experiments on cross-infection, the infectivity of cysts of different ages, superimposed infections and the rate of loss of worms.

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LIFE HISTORY OF *Hamacreadium gulella* LINTON 1910

The cercaria of *H. gulella* was first found at Tortugas in *Astraea americana* by Miller (1925) and briefly described under the name Cercaria B. It is a typical cotylocercous cercaria possessing a thick-walled excretory vesicle, stylet and stylet glands, and the characteristic stumpy tail modified into a sucker.

The cercariae develop in large, elongate sporocysts which measure nearly 3 mm. in length and contain as many as 75 cercariae in all stages of development. The anterior ends of the sporocysts are actively protrusible. The walls contain large masses of bright orange pigment, a fact which makes it possible to distinguish infested snails with the naked eye. The gonad is normally white in male snails and green in the females, but in infested snails it is definitely orange in color. The number of infested snails was very small, only 29 out of 3,669 or 0.8 per cent.

TABLE 1.—*Size Measurements of Stages in the Life Cycle of* Hamacreadium gulella

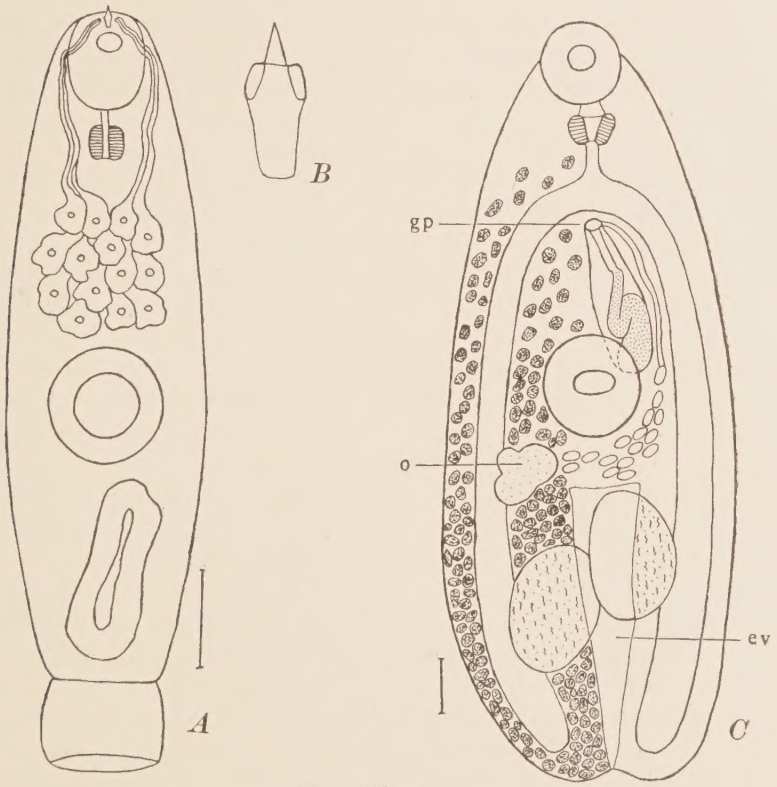
All figures are in mm. and are the average measurements of from 5 to 10 specimens killed by gentle heat.

	Length of Body	Width of Body	Oral Sucker	Ventral Sucker	Pharynx
Cercaria	0.337	0.097	0.057	0.065	0.022
Developing worms— 6 days in fish...	0.513	0.214	0.105	0.140	0.052
Developing worms—12 days in fish...	0.781	0.366	0.156	0.224	0.082
Adult worms—19 days in fish.....	1.340	0.480	0.213	0.310	0.133

The body of the cercaria of *H. gulella* is elongate (Fig. *A*) and is not spined. The tail is very short, 31 by 54 μ, is cup-shaped, and is used as a sucker. The ventral sucker is slightly larger than the oral sucker. A small single-pointed stylet 13 μ in length is present (Fig. *B*). The most conspicuous feature of the body is a mass of 14 large granular stylet glands located just anterior to the ventral sucker. Ducts from these glands pass forward in two bundles one on each side of the body and open along side of the stylet. A pharynx is present immediately posterior to the oral sucker but no other parts of the digestive system were distinguished. The excretory vesicle which occupies the posterior part of the body is elongate and non-bifurcated, and has thick-walls composed of large granular cells. The flame cell pattern of the excretory system was not determined. Size measurements of the cercaria are given in Table 1 in comparison with those for other stages in the life cycle.

The cercaria of *H. gulella* is very similar morphologically to the cercaria of *H. mutabile* but there are several points which distinguish the two species. The cercaria of *H. gulella* is considerably larger than the cercaria of *H. mutabile* and most notably contains 14 stylet glands

instead of 8. Since the nuclei of these glands may be counted under low power magnification, identification of the species is certain and comparatively easy. A further difference may be seen with the naked eye. The sporocysts of the cercaria of *H. gulella* are very easily freed from the gonad of the infested snail, whereas those of the cercaria of *H. mutabile* remain tangled in the tissues and are separated only with great difficulty.



TEXT FIGURES

Hamacreadium gulella. *A*, Ventral view of cercaria. *B*, Stylet of the cercaria. *C*, Ventral view of sexually mature specimen taken from intestine of gray snapper 19 days after infestation. Abbreviations: *ev*, excretory vesicle; *gp*, genital pore; *o*, *ovary*. The scale in *A* equals 50μ; in *C* it equals 100μ.

Apparently the cercariae of *H. gulella* will penetrate and encyst in practically any small fish as second intermediate host, for experimentally they encysted in representatives of 10 common genera selected at random from the small fish brought into the laboratory. The cercariae encysted within 12 hours after penetrating the fish and the cysts were thin-walled and transparent. They were found principally in the soft tissues around

the mouth and gills. The average size of 10 cysts 7 days old was 261 by 155 μ. The metacercariae 7 days after penetration showed only slight changes in structure from the cercarial stage. The tail and stylet were no longer present, the stylet glands had disintegrated, and the excretory vesicle was enlarged and contained numerous small concretions. The digestive tract with narrow ceca extending to the posterior end of the body had definitely appeared. The body also showed a slight increase in size.

The development of the adult worms in the gray snapper was established by a large number of feeding experiments which will be reported in detail in later sections of this paper. Suffice it to say that the life cycle could readily be completed in the laboratory and that there was no doubt whatsoever in identifying the cercaria as the larva of *Hamacreadium gulella*. The development of the worms in the snapper took place quite rapidly. Six days after the feeding of the cysts, the worms had increased greatly in size and the testes had started to develop. After 12 days the cirrus pouch was formed and the male reproductive system was completely developed. Parts of the female system had also appeared. In from 15 to 19 days, the worms became sexually mature with eggs present in the uterus (Fig. c). The time required for *Hamacreadium mutabile* to become sexually mature is somewhat longer, 20 to 25 days. The worms do not reach their maximum size, however, until after about 30 days.

The adults of *H. gulella* and *H. mutabile* are most easily distinguished by the fact that in *H. gulella* the excretory vesicle reaches only to the anterior border of the testes, whereas in *H. mutabile* it extends well anterior to the ventral sucker. Also, in *H. gulella* the genital pore is median instead of on the left side as in *H. mutabile*. Furthermore, *H. mutabile* is definitely larger than *H. gulella*, specimens 30 days old averaging 2.6 mm. in length as compared with 2.0 mm.

Although the cercaria of *H. gulella* is able to encyst in a variety of small fish experimentally, under natural conditions, it seems probable that only two species, the bluehead, *Thalassoma bifasciatum*, and the slippery dick, *Halichoeres bivittatus*, act as intermediate hosts. Over a period of two months, gray snappers kept in a live car were fed with small grunts, parrot fish, and various other small fish and no infections with *H. gulella* were noted. However, when blueheads and slippery dicks were fed to the snappers, infections of one or two worms occurred in most of the fish. Also, on one occasion a cyst of *H. gulella* was found in the tissues of a slippery dick. No other natural occurrences of the cysts had ever been found in numerous other small fish examined.

The conclusion that the bluehead and slippery dick are the natural intermediate hosts of the worm is further substantiated by the fact that these fish have a certain habit which would expose them to infestation

by the cercariae. Since the tail of cotylocercous cercariae is of no aid in swimming, the cercariae are unable to support themselves in the water and sink to the bottom. Hence their possibilities of reaching a second intermediate host are limited to those forms which come near the bottom. In small aquaria the cercariae of *H. gulella* habitually attach to the bottom with their sucker-like tails and wave their bodies back and forth through the water. The bluehead and slippery dick swim about actively during the daytime, but at night they burrow in the sand presumably to escape their predaceous enemies. They are thus exposed to infestation by the cercariae which are attached to the bottom. The completion of the last link in the life cycle, is not difficult to imagine because it is known that the gray snapper frequently devours blueheads and slippery dicks. It is interesting to find evidence for such a perfect correlation of the structure and behavior of the cercaria with the habits of its hosts.

A further point of general biological interest is the exact parallelism between the life cycles of *Hamacreadium gulella* and *H. mutabile*. These two species occur in the same fish host and have their larval stages in the same snail, and yet show certain definite structural differences in both the larval and adult stages. The question arises as to how species differentiation occurred in an environment which must have been uniform throughout the life cycle of the parasite.

CROSS-INFECTION EXPERIMENTS

Natural infestations of *H. gulella* have been reported only from the gray snapper. On the other hand Linton (1910) reported *H. mutabile* from five different hosts, three species of the snapper family, Lutianidae, and two from other families. The reports in the two latter cases, however, were of single immature specimens and may be incorrect. Since large numbers of infective cysts of the two species of worms were available, it was possible to test experimentally their development in different fish. In all feeding experiments, control tests were made by feeding small fish containing the cysts to gray snappers.

The development of *H. gulella* was tested in 8 species of fish representing 6 different families (see Table 2). Three yellow-tails were fed, but all other species were represented by only one specimen. It will be noted that the worms developed only in the three species belonging to the snapper family, Lutianidae. The schoolmaster and yellow-tails were killed after 7 days, so it is not possible to say whether the worms would have become sexually mature in these hosts.

The development of *H. mutabile* was tested in six species of fish representing five different families. Five of these species are designated in Table 2 while the sixth was the common grunt, *Haemulon plumieri*, of the family Haemulidae. Again it was found that the worms developed only in species of the family Lutianidae. In this experiment it was

shown that *H. mutabile* could reach sexual maturity in the yellow-tail in about the same length of time that is required in the gray snapper.

These cross-infection experiments demonstrate that although infection with the two species of Hamacreadium is not restricted to a single species of fish, it is, as far as the evidence goes, limited to members of the snapper family. The feeding experiments were carried out quantitatively but the numbers are too few to justify definite conclusions. However, there is incomplete evidence that a larger proportion of the worms develop in the gray snapper than in the yellow-tail, indicating that the parasites are better adapted to the former host. Under natural conditions, about 70 per cent of the gray snappers harbor either one or both species of Hamacreadium, whereas only one out of eight yellow-tails examined contained a single immature specimen of *H. mutabile*.

INFECTIVITY OF CYSTS OF DIFFERENT AGES

Two sets of experiments were carried out to determine how old the cysts had to be before they were infective. One lot of small fish was

TABLE 2.—*Development of* H. gulella *in Different Fish*

Common Name	Scientific Name	Family	Result
Gray snapper*	*Lutianus griseus*	Lutianidae	Positive
Yellow-tail*	*Ocyurus chrysurus*	Lutianidae	Positive
Schoolmaster	*Lutianus apodus*	Lutianidae	Positive
Nassau grouper*	*Epinephelus striatus*	Serranidae	Negative
Black angel fish*	*Pomacanthus arcuatus*	Chaetodontidae	Negative
Porgy	*Calamus calamus*	Sparidae	Negative
Yellow jack	*Caranx bartholemei*	Carangidae	Negative
Chub*	*Kyphosus incisor*	Kyphosidae	Negative

* Same result obtained in feeding cysts of *H. mutabile*.

infected with the cercaria of *H. gulella* and another lot with the cercaria of *H. mutabile*. In this and subsequent experiments the small fish were infected according to the following procedure. Small yellow grunts, *Haemulon sciurus*, caught in a seine, were brought into the laboratory and sorted into lots of approximately the same size. The size range of the fishes used was approximately 2.5 to 5 cm. measured from the anterior tip to the base of the caudal peduncle. This species of fish could be easily handled and readily kept alive in laboratory aquaria over a period of several weeks.

Cercariae were collected by teasing apart the sporocysts from snails harboring mature infestations. Usually from 3 to 5 infested snails furnished enough mature cercariae to infect 100 to 150 small fish. The cercariae were made up into a suspension and divided into four equal portions which were added to large crystalizing dishes containing 500 cc. of water. From 30 to 40 small grunts were then exposed in each dish for a period of 3 hours. During this time in order to keep the

fish alive it was necessary to keep a continual stream of oxygen bubbling through the water. The majority of fish survived this exposure, the amount of infestation depending upon the number of cercariae in the dishes.

In any given experiment, the small fish to be used were all exposed under identical conditions and subsequently put together in one aquarium. The fish to be fed to the individual snappers were then selected at random from this lot. The number fed usually varied from 3 to 8 depending upon the number of snappers in the series and the number of small fish available. Since the cysts were located in the tissues of the fish, there was no way to count the actual number present. It was only possible to give approximately equal doses to a series of snappers by feeding them the same number of small fish. The accuracy of the method may be judged from the variation in the number of worms recovered from the fish at autopsy. The coefficient of variation calculated on 5 series of fish varied from 20 to 40 per cent (data from Tables 3, 4, 6 and 7). Considering the fact that in addition to sampling variation in the number of cysts fed, there are probably differences in the susceptibility of the snappers to infection, these coefficients of variation do not seem abnormally high. At least, the variation is no greater than is found in the development of some other parasites in which the dose of larvae may be actually counted.

The small fish were fed to the snappers by forcing them down the throat with a pair of forceps. This method was found to be the quickest and most certain. The snappers were then kept in a large, partitioned live-car anchored in the ocean, and were fed on small minnows and waste food from the kitchen. The gray snapper is naturally a hardy fish, and lived satisfactorily under these conditions. In all experiments, adult snappers of approximately the same size (about 22 cm. long) were used. Fish were conveniently marked by clipping the fins.

In the first experiment a number of small fish were infected with the cercaria of *H. mutabile* and fed to a series of 18 gray snappers after various intervals. Three snappers were fed at each interval and each was given 3 small fish. The snappers were all killed 9 days after feeding. The results are tabulated in Table 3. The cysts were not infective on the first or second day after the cercariae had penetrated the fish. About half of them were infective on the third day and all on the fourth. Apparently, the infectivity did not increase or diminish for cysts up to 12 days of age.

A similar experiment was carried out with cysts of *H. gulella* and identical results were obtained (see Table 4). These experiments were undertaken primarily to determine how long it was necessary to keep the small fish after infection with the cercariae before they could be used

for feeding experiments. Four days is apparently sufficient time, but in all experiments they were kept for at least five days before being used. The results also demonstrate that at least two days of development in the metacercarial stage is biologically necessary in the life cycles of the worms.

TABLE 3.—*Infectivity of Cysts of Different Ages*—Hamacreadium mutabile

Fish Number	Number of Small Fish Fed	Age of Cysts	Killed, Days After Feeding	Number of Worms Recovered
Snapper #32	3 fish	1 day	9 days	6*
Snapper #33	3 fish	1 day	9 days	0
Snapper #34	3 fish	1 day	9 days	0
Snapper #35	3 fish	2 days	9 days	3*
Snapper #36	3 fish	2 days	9 days	0
Snapper #37	3 fish	2 days	9 days	3*
Snapper #39	3 fish	3 days	9 days	131
Snapper #40	3 fish	3 days	9 adys	202
Snapper #41	3 fish	3 days	9 days	126
Snapper #42	3 fish	4 days	9 days	320
Snapper #43	3 fish	4 days	9 days	542
Snapper #48	3 fish	6 days	9 days	171
Snapper #49	3 fish	6 days	9 days	375
Snapper #50	3 fish	6 days	9 days	151
Snapper #51	3 fish	6 days	9 days	396
Snapper #64	3 fish	12 days	9 days	259
Snapper #65	3 fish	12 days	9 days	198
Snapper #66	3 fish	12 days	9 days	354

* Apparently these worms were from an accidental infestation; young worms appeared in control fish at about this same time.

TABLE 4.—*Infectivity of Cysts of Different Ages*—Hamacreadium gulella

Fish Number	Number of Small Fish Fed	Age of Cysts	Killed, Days After Feeding	Number of Worms Recovered
Snapper #46	3 fish	1 day	6 days	0
Snapper #47	3 fish	1 day	6 days	0
Snapper #52	3 fish	2 days	6 days	0
Snapper #53	3 fish	2 days	6 days	0
Snapper #54	3 fish	3 days	6 days	229
Snapper #55	3 fish	3 days	6 days	170
Snapper #56	3 fish	4 days	6 days	21
Snapper #57	3 fish	4 days	6 days	590
Snapper #61	3 fish	6 days	6 days	285
Snapper #62	3 fish	6 days	6 days	513
Snapper #63	3 fish	6 days	6 days	402
Snapper #68	3 fish	8 days	6 days	411
Snapper #69	3 fish	8 days	6 days	169

RATE OF LOSS OF WORMS

In following the development of *H. gulella* in a series of five snappers killed at different intervals after feeding, it was noted that the number of worms greatly decreased in the older infestations. In fact the last two snappers killed after 26 and 29 days respectively did not harbor any worms at all, even though they had received the same dose of cysts as had a snapper which contained 147 worms when killed after 6 days (Table 5, Exp. 1).

To verify this observation a series of 8 snappers were given a heavy dose of cysts and two snappers killed after 3, 6, 15 and 24 days (Table 5, Exp. 2). The first two fish examined after 3 days harbored 473 and 320 worms respectively. The second pair killed on the sixth day after feeding contained 311 and 25 worms. This latter fish undoubtedly had received as large a dose of cysts as the other fish but either the large majority of the worms failed to develop or else they had been thrown

TABLE 5.—*Loss of* Hamacreadium gulella *in Experimental Infestations in Gray Snapper*

Fish Number	Number of Small Fish Fed	Age of Cysts	Killed, Days After Feeding	Number of Worms Recovered
	Experiment 1—Large Number of Cysts Fed			
Snapper #2	3 fish	7 days	6 days	147
Snapper #6	3 fish	7 days	12 days	35
Snapper #7	3 fish	7 days	19 days	24
Snapper #8	3 fish	7 days	26 days	0
Snapper #10	3 fish	7 days	29 days	0
	Experiment 2—Large Number of Cysts Fed			
Snapper #23	5 fish	6 days	3 days	320
Snapper #24	5 fish	6 days	3 days	473
Snapper #27	5 fish	6 days	6 days	311
Snapper #28	5 fish	6 days	6 days	25
Snapper #44	5 fish	6 days	15 days	6
Snapper #45	5 fish	6 days	15 days	22
Snapper #78	5 fish	6 days	24 days	0
Snapper #79	5 fish	6 days	24 days	4
	Experiment 3—Large Number of Cysts Fed			
Snapper #58	4 fish	15 days	3 days	386*
Snapper #59	8 fish	5 days	15 days	103
Snapper #60	8 fish	5 days	15 days	116
Snapper #82	8 fish	5 days	20 days	28
Snapper #83	8 fish	5 days	20 days	6
Snapper #84	8 fish	5 days	20 days	11
Snapper #86	8 fish	5 days	20 days	0
	Experiment 4—Small Number of Cysts Fed			
Snapper #17	21 fish	8 days	3 days	4
Snapper #18	21 fish	8 days	3 days	12
Snapper #20	21 fish	8 days	6 days	10
Snapper #22	21 fish	8 days	9 days	11
Snapper #26	21 fish	8 days	14 days	4
Snapper #38	21 fish	8 doys	20 days	5
Snapper #67	21 fish	8 days	30 days	9

* This figure should be considered as 772 in comparing it with the other figures in the series. This fish was given only one half the dose of cysts that the other fish received.

off within the period of 6 days. A similar case occurred in the experiment testing the infectivity of the cysts of *H. gulella* (see Snapper No. 56, Table 4). This fish contained only about one-twentieth of the number of worms harbored by 6 other snappers, all given the same dose of cysts and killed 6 days after feeding.

The third pair of fish in experiment 2 examined after 15 days contained 22 and 6 worms respectively, only about 4 per cent of the estimated number originally harbored. Of the last two fish killed after 24 days, one contained 4 worms while the other was completely negative.

The rapid loss of worms in heavily infested fish is further substantiated by the data from another experiment carried out for a different purpose but tabulated in Table 5 as experiment 4. In this series of 7 fish the first snapper killed 3 days after feeding, contained 386 worms. Since this fish received only half as many cysts as the other snappers, this number should be multiplied by 2 and considered as 722 in comparing with the others in the series. Two other fish killed after 15 days harbored 116 and 103 worms respectively, while the last four killed after 20 days contained infestations varying from 28 worms to none at all. Again, there had been a rapid and in one instance a complete loss of worms over a period of 3 weeks after infestation.

A fourth series of snappers were fed a large number of small fish (Table 5, Exp. 4) but apparently the cercariae used had been immature and the small fish contained very few cysts, for only a small number of worms developed in the snappers. Two fish killed after 3 days harbored infestations of 12 and 4 worms each. The other five fish were killed at various intervals over a period of 30 days, and all contained infestations within this range. In this one series when only a small number of cysts were fed, the worms which developed were not lost but were recovered as long as 30 days after infection. This experiment is probably similar to the conditions of natural infection in which apparently only a very few cysts are ingested. Natural infestations of *H. gulella* seldom amount to as many as 6 worms, usually not more than one or two.

No definite experiments were carried out with *H. mutabile* to test the rate of loss of worms, but judging from the evidence from various miscellaneous feeding experiments, if the loss does occur in the heavy infestations, it is not nearly as rapid nor as complete as with *H. gulella*. It would be interesting to compare the two species in this respect, because natural infestations of *H. mutabile* are somewhat larger and considerably more frequent than those of *H. gulella*.

SUPERIMPOSED INFECTIONS

Two sets of experiments were undertaken to determine whether the presence of a large infestation of worms would confer any resistance against the establishment of a second infection. In the first experiment, four snappers from a lot of eight were given a fairly large dose of cysts. The other four fish were kept as controls. After 16 days all eight fish were fed a heavy dose of cysts, and after 6 days more they were killed and examined (see Table 6). The four fish which had been previously infected developed large second infestations, ranging from 36 to 144 worms and averaging 90. The parallel infestations in the four control fish were somewhat larger ranging from 107 to 221 worms and averaging 148. The difference between the averages of the

two groups is 58 ± 19.6, a difference which in the light of its probable error is just on the border line of significance. A sample of 25 worms from each fish were measured, but the size of the worms from the previously infested fish was not significantly different from that of the worms from the control fish.

TABLE 6.—*Superimposed Infections with* Hamacreadium mutabile

Sixteen days interval between first and second infections. Size in micra

Fish Number	Number of Small Fish First Feeding	Number of Small Fish Second Feeding	Killed, Days After Second Feeding	Worms From First Infection	Worms From Second Infection	Size of Worms, Second Infection
			Experimental Fish Infected Twice			
Snapper #70	7 fish	7 fish	6 days	40	85	552
Snapper #73	7 fish	7 fish	6 days	64	144	533
Snapper #74	7 fish	7 fish	6 days	126	94	605
Snapper #75	7 fish	7 fish	6 days	25	36	672
Average				64	90	591
			Control Fish Infected Once			
Snapper #71	.....	7 fish	6 days	...	221	645
Snapper #72	.....	7 fish	6 days	...	120	636
Snapper #76	.....	7 fish	6 days	...	107	534
Snapper #77	.....	7 fish	6 days	...	144	598
Average				...	148	604

TABLE 7.—*Superimposed Infections with* Hamacreadium gulella

Fifteen days interval between first and second infections. Size in micra

Fish Number	Number of Small Fish First Feeding	Number of Small Fish Second Feeding	Killed, Days After Second Feeding	Worms From First Infection	Worms From Second Infection	Size of Worms, Second Infection
			Experimental Fish Infected Twice			
Snapper #82	8 fish	5 fish	5 days	28	534	565
Snapper #83	8 fish	5 fish	5 days	6	519	504
Snapper #84	8 fish	5 fish	5 days	11	306	456
Snapper #86	8 fish	5 fish	5 days	0	427	377
Average				9	447	476
			Control Fish Infected Once			
Snapper #80	.....	5 fish	5 days	...	950	589
Snapper #81	.....	5 fish	5 days	...	572	573
Snapper #85	.....	5 fish	5 days	...	640	540
Snapper #87	.....	5 fish	5 days	...	672	617
Snapper #88	.....	5 fish	5 days	...	583	587
Average				...	683	581

A similar experiment was carried out with *H. gulella* (see Table 7). It should be noted that the fish were not killed until 20 days after the first infection, and that the number of worms recovered is not an adequate estimate of the size of the first infestation because more than 95 per cent of the worms had been lost by that time. (Compare Snappers No. 58, No. 59 and No. 60 from the same series, Table 5, Exp. 3 which show that the original infestation was almost certainly more than

500 worms.) The average number of worms which developed from the second feeding in the previously infested fish was 447 as compared with 683 the number which developed in the control fish. In this case the difference is 236 ± 51.7, more than 4½ times its probable error and hence almost certainly significant. The sizes of the worms recovered from the two sets of fish were also significantly different, the worms from the previously infested fish averaging 476 μ as compared with 581 μ, the average of those in the control fish. The difference is 105 ± 25.6.

It is evident from these experiments that a previous heavy infestation did not confer any very appreciable resistance against a second infection. However, in the experiment with *H. gulella* there was significant evidence that the second infestation was not quite as large in previously infested fish as in control fish. Also, the size of the worms in previously infested fish was significantly smaller.

DISCUSSION

The foregoing experiments indicate how some of the relations between trematode parasite and fish host may be studied on a quantitative basis. However, there are certain disadvantages in the method of study which are impossible to avoid. It is not possible to count accurately the number of cysts fed. It is only possible to give approximately equal doses to a series of fish. Also, the course of the infection cannot be followed in any way except by killing fish from a parallel series at various intervals. Consequently the scope of any experiment is definitely limited because of the large numbers of animals required. Furthermore, since the snappers used are adults caught in the open ocean, it is impossible to avoid natural infestations of the parasites in experimental fish. It should be pointed out, however, that only about 60 per cent of the fish harbor natural infestations, which when they do occur are usually only one or two worms, very seldom as many as 10. In any event, since the age of the experimental worms is known, it is practically always possible to distinguish them from the few worms which may be present from a natural infestation.

The most striking of the experimental results is that fish given a heavy infestation of *Hamacreadium gulella* lost practically all of the worms before or very soon after they reached sexual maturity. Crowding of the worms could not have been responsible, for that factor would not have continued to operate after the numbers of worms had been reduced. It does not seem possible that the loss could have been due to the dying off of the worms because they were not yet full-grown by the time they were thrown off. It might be suggested that the fish lost the worms because they were kept in captivity. In all experiments

the snappers were kept in a large live car in the open ocean, and they did not lose their natural infestations with other parasites. Also, the worms from the experimental feeding persisted in the fish which were given only a small number of cysts. From the present evidence the most logical explanation for the loss of worms seems to be that under the stimulus of a heavy infestation of several hundred worms, the fish are able to react against the worms in some way so that the infestation is completely thrown off.

SUMMARY

The life history of *Hamacreadium gulella* Linton, 1910, a trematode parasite of the gray snapper, *Lutianus griseus,* was found to parallel exactly that of *H. mutabile* Linton, 1910, also parasitic in the gray snapper. Both cercariae are of the cotylocercous type, occur in the same snail host, *Astraea americana,* and encyst in various small fish. The bluehead, *Thalassoma bifasciatum,* and slippery dick, *Halichoeres bivittatus,* are apparently the natural second intermediate hosts.

In cross-infection experiments both *H. mutabile* and *H. gulella* developed only in fish of the snapper family, Lutianidae, and failed to develop in numerous other species tested.

A method is described for administering approximately equal doses of cysts to a series of fish and studying infections quantitatively.

Cysts were not infective on the first or second day after the cercariae had penetrated the fish; about half of them were infective on the third day and all on the fourth. The infectivity did not increase or diminish for cysts up to 12 days of age.

A heavy previous infection of snappers with either *H. mutabile* or *H. gulella* did not confer any very appreciable resistance against a second infection. There is evidence, however, that with *H. gulella,* the second infestation in previously infested fish was not quite as great as in control fish.

Snappers given an infestation of several hundred *H. gulella* lost practically all of the worms within a period of 4 weeks. In a single experiment fish given only a light dose of cysts, 10 to 15, did not lose the worms. The rapid and in many instances complete loss of worms in heavily infested fish is apparently caused by some reaction of the fish against the parasite.

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THE EXCRETORY SYSTEM OF *CERCARIAEUM LINTONI* MILLER 1926*

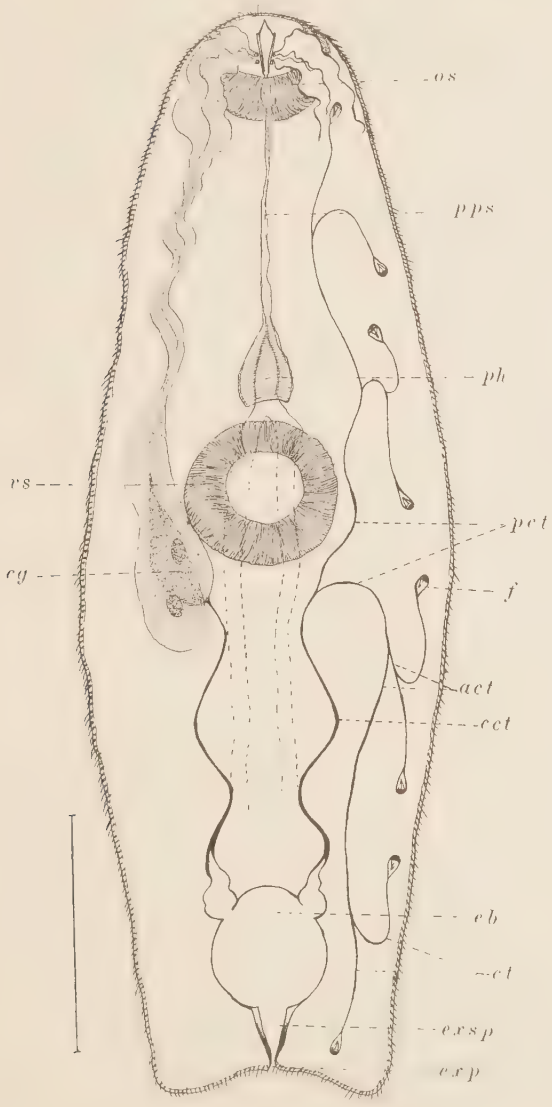
CANDIDO M. AFRICA

This tailless marine larva was first described by Linton (1915) from *Nassa obsoleta* of the Woods Hole region and further described by Miller (1926) who placed it in the provisional generic group Cercariaeum. Its excretory system, however, still remains to be described. The writer while engaged in dissecting a considerable number of specimens of this same species of snail from Cold Spring Harbor, Long Island, New York, was afforded an opportunity to study and make out the excretory system of this larva. On account of the numerous refractile granules which obscured the capillary tubes and flame cells especially of the region behind the ventral sucker, great difficulty was experienced in making out these structures. In fact, the exact connection of the two flame cells of the posterior group has not been made out with certainty, but judging from the connections of the anterior apparently homologous groups, they are most likely drained by a common accessory tube just as their anterior neighbors are. It seems quite certain, however, that there are eight flame cells on each side, for in the study of more than a hundred individual specimens there had been no instance when a count of more than eight on either side was made. In this study the method of Cort (1917) for studying trematode larvae has been used.

The excretory system of *Cercariaeum lintoni* (fig. 1) is relatively simple. The common collecting tubes which are large and wavy, form a figure roughly resembling a lyre between the ventral sucker and the excretory bladder which they join at its anterior border. On either side, the common collecting tube receives, just posterior to the ventral sucker, the anterior and posterior primary collecting tubes, each of the latter in turn receiving two accessory tubes. Each accessory tube receives two capillary tubules, each of which in turn drains a flame cell. The eight pairs of flame cells, therefore, are distributed quite evenly, each draining an approximately equal area. The four anterior pairs of flame cells are preacetabular while the four posterior ones are postacetabular. The excretory formula is as follows: $2\ (2+2) + (2+2) = 16$ flame cells.

In the course of this study an unusual opportunity was afforded to observe and study the mechanism by which the excretory bladder seems to rid itself of its waste material. An enterprising larva happened to

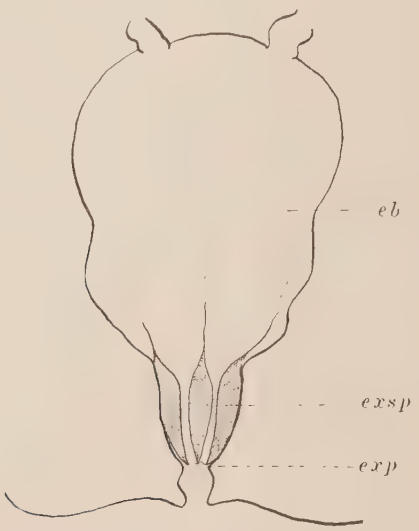
* From the Department of Helminthology of the School of Hygiene and Public Health of the Johns Hopkins University.



Text figure 1.—The excretory system of *Cercariaeum lintoni* Miller 1926. Ventral view. Diagramatic free hand drawing of a living specimen. Abbreviations: *os*, oral sucker; *vs*, ventral sucker; *pps*, prepharynx; *ph*, pharynx; *cct*, common collecting tubule; *pct*, primary collecting tubule; *f*, flame cell; *act*, accessory collecting tubule; *eb*, excretory bladder; *exp*, excretory pore; *cg*, cephalic glands; *ct*, capillary tubule. Scale represents 50μ.

be incarcerated in a tight film of moisture which was surrounded by an air cell, and while struggling to disengage itself an unusual view of its posterior end was exposed to a prolonged observation. Before proceeding, however, a brief description of the excretory bladder and its accessory sphincter will be presented in order to understand more fully the nature of this mechanism.

Judging from its incessant contraction and relaxation, the bladder wall is without doubt provided with an elaborate musculature. In fact, according to Looss (1894), who made an extensive study of the structures of young trematodes, the bladder wall is provided with an inner circular and an outer longitudinal strands of muscles, which in both



Text figure 2.—Diagramatic free hand drawing of the excretory bladder and its sphincter. Ventral view. Abbreviations: *exp,* excretory pore; *eb,* excretory bladder; *exsp,* excretory sphincter.

instances do not run parallel to one another, thus forming a sort of an irregular lattice. The bladder cavity is lined with large nucleated epithelial cells which are provided with tufts of hair-like processes or cilia which hang free in the bladder cavity. Looss did not mention the function of these cilia, but it seems quite logical to postulate that they assist in driving the waste material toward the sphincter. No opportunity to verify these structures has been afforded in the present study, but they have been assumed to be present in this cercariaeum as the general build of the trematode larvae is more or less fundamentally similar throughout. At its posterior end the excretory bladder is capped with a prominent funnel-shaped sphincter which appears to be mem-

branous and supported or strengthened at intervals by six definite thickenings or ribs matted together not unlike the ribs of an umbrella. The rim of the sphincter marks the lower boundary of the bladder cavity proper, while its apex defines the position of the excretory pore which opens on the center of the truncated end of the larva which Miller (1926) calls the adhesive disk. In fact, the apex of the sphincter forms the excretory pore itself as will be seen presently. The exact nature of these supporting ribs is not known, but they seem to be downward extensions of the muscles of the bladder wall which have been modified and assigned to a special function, that of giving strength and support to the membranous sphincter. They seem to be rigid structures or if they are possessed of any power of contraction it is certainly very feeble or limited.

The mechanism by which the bladder and its accessory sphincter seem to function is as follows:

When the bladder is relaxed or in the position of rest, the roots of the supporting ribs of the sphincter are spread apart, forming the upper rim of this funnel-shaped organ. At the same instant their posterior tips are converged to a fine point, thereby throwing the posterior margin of the sphincter membrane into folds and closing the excretory pore. In the meantime waste material is being driven into the sphincter cavity by the active vibration of the cilia which line the walls of the bladder cavity. When the bladder contracts, the roots of the ribs are squeezed and drawn together. The upper rim of the sphincter is thus obliterated, and simultaneously the posterior tips of the ribs are spread apart, thereby stretching and effacing the folds of the excretory pore and widening this opening to allow the passage of the waste material to the exterior. As the bladder relaxes again, the upper ends of the ribs are brought again to their former position of rest, thereby automatically closing the excretory pore. In other words, when the rim of the sphincter is closed the excretory pore is open and vice versa. This rhythmic contraction and relaxation of the bladder took place at irregular intervals varying from ten to thirty seconds during the period that the larva was under observation. It was observed to be more vigorous and frequent during the period of its activity than when the larva was already exhausted and had ceased to move.

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PRESENCE OF THE LANCET FLUKE, *DICROCOELIUM DENDRITICUM* (RUDOLPHI 1819), IN CANADA

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On December 1, 1929, specimens of sheep livers were received from the Lake St. John region of Quebec. The animals were reported as having had "liver trouble" and of five sheep three had died. Flukes were located in large numbers in the sheep livers and the parasite identified as *Dicrocoelium dendriticum* (Rudolphi 1819). The five infested sheep had been brought in from Nova Scotia. The two surviving sheep were slaughtered after diagnosis of the trouble had been made. The same species of fluke, as above, was later found and identified from a section of sheep liver received from Nova Scotia on December 16, 1929. On March 10, 1930, examination of a carcass of a mink received from Prince Edward Island disclosed the presence of the same parasite as noted above.

In the liver, gall bladder, pancreatic duct and duodenum the parasites were present in large numbers. The livers were enlarged and at the pole more spongy than cirrhotic.

DESCRIPTION OF PARASITE

Small trematode, body pointed anteriorly and posteriorly; attenuated anteriorly, and the greatest breadth usually behind the middle of the body; length 5.1 to 7.0 mm. and breadth 1 to 1.4 mm. Oral and ventral suckers present. Ventral sucker same size as oral sucker or slightly larger (0.3 mm.); two suckers separated from each other by about one fifth length of body (by same distance as the length of the vitellaria). Surface of body smooth. Intestine divides anterior to the genital pore; intestinal ceca about three fifths of body length, broadening rather slightly at their free ends. Testes two in number, smoothly indented, and lying obliquely behind the ventral sucker; posterior testis usually slightly the larger (0.4 to 0.55 mm.). Vasa deferentia run forward to cirrus pouch from anterior margins of testes. Ovary single, considerably smaller than testes (0.2 mm.); it approaches the median line behind the posterior testis and is not indented on its margin in the same manner as the testes. Vitellaria (yolk glands) double, commencing posterior to

caudal margin of second testis and terminating near commencement of slight swelling of distal ends of intestinal ceca; with fingered outline on both ental and ectal margins. The conspicuous uterus is situated behind the ovary, filling most of the body caudad to that organ; with many transverse coils sent out to the lateral fields. The uterus finally terminates in a narrow tube which runs forward, between the two testes, to the ventral sucker and terminates at the genital pore. Cirrus and cirrus-pouch located slightly anterior to ventral sucker. Seminal receptacle present, located caudad to ovary and slightly to one side. Shell gland present on median line behind ovary. Laurer's canal distinct. Eggs of parasite thick shelled and varying in color according to age; when young they are yellowish and when older dark brown. The eggs are oval, operculated at one end and frequently flattened on one side; size 0.3 to 0.4 mm. by 0.15 to 0.2 mm.

In addition to localities cited herein, this fluke has been recorded as occurring in Germany, Italy, Africa, Siberia, Turkestan, Egypt, Algeria, and South America. The parasite has not previously been recorded as occurring in Canada or the United States. It has been previously reported from man, ox, ass, goat, horse, deer, hare, rabbit, sheep and pig. Species of snails (*Planorbis*) have been suspected as the intermediate hosts of this fluke.

The identification of this fluke was confirmed by the Bureau of Animal Industry, Department of Agriculture, Washington, D. C., to whom we are continually indebted for many services.

STUDIES ON SOME NEMATODES OF NORTH AMERICAN AMPHIBIA. II. CRYPTOBRANCHIDAE.*

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With the exception of *Filaria cingula* Linstow 1902, originally reported from *Cryptobranchus maximus,* but later redescribed and figured by Krecker (1915) from *Cryptobranchus allegheniensis,* no reported occurrence of nematode parasites in members of the Cryptobranchidae of North America has come to the attention of the author. While using *Cryptobranchus allegheniensis* as a laboratory animal careful examination was made for examples of *Filiaria cingula,* but not a single specimen was found in over one hundred animals examined. Attention was drawn, however, to the presence of both cestode and nematode parasites of the intestinal tract. Upon comparison the nematodes were found to be identical with forms in the collection of Dr. Henry B. Ward of the University of Illinois and the following descriptions are based upon the material from these two sources. All of the host forms were obtained originally from Pennsylvania rivers.

Two of the new forms belong to the family Kathlaniidae (Spironoura = Falcaustra, and Zanclophorus) and the third to the family Spiruridae (Spiroxys). Species of the first genus are normally parasites of tortoises, snakes and fishes; those of the second genus of tortoises; and those of the third genus of tortoises and snakes. In a recent paper (Walton 1929) the author has reported a species of Falcaustra (= Spironoura) in the Bullfrog. The present paper therefore adds another Amphibian host to the list of those recorded for the genus Spironoura and also for the first time records Amphibian hosts for members of the genera Zanclophorus and Spiroxys.

Spironoura cryptobranchi n. sp. [fig. 1]

Only female examples of this form were found, being obtained from the large intestine of *Cryptobranchus allegheniensis.* These worms are stout, rather large forms, with the characteristic three lips of the genus, each lip bearing two distinct external and two very poorly developed internal papillae. At the base of each lip is a collar-like cuticularized ring which seems to point to some affinity of this species thus distinctively marked to the genus Zanclophorus. The cuticula is smooth, entirely lacking any lateral ridges or alae. The vestibule is supported by

* Contribution from the Biological Laboratories of Knox College, No. 34.

a chitinized ring which seems to give rise to the internal papillae. The short muscular pharynx has a very definite cuticularized lining, apparently lacking cutting plates. The long esophagus terminates in a distinctly hour-glass-shaped posterior bulb which is provided with three cutting plates in its posterior dilatation. The bulb opens into the intestine through a three-lobed cuticularized cardia. The tail tapers gradually to a sharply pointed tip. The vulva is toward the posterior third of the body. The ovejector is muscular and opens into opposed uteri. The eggs are unsegmented at the time of entering the ovejector and the species is apparently oviparous.

Female.—Body length, 15 to 16 mm.; width at vulva, 0.45 to 0.5 mm.; length of pharynx, 0.1 mm.; length of esophagus and anterior bulb, 1.5 to 1.6 mm.; diameter of posterior esophageal bulb, 0.16 by 0.17 mm.; nerve-ring, 0.45 to 0.5 mm. from the lips; vulva-anus distance, 3.8 to 3.9 mm., and anus-tail distance, 2.7 mm.

The presence of the peculiar type of cuticular lip-support differentiates this form from any thus far reported for either Spironoura or Zanclophorus, and while, in the absence of the male, it is impossible to accurately place the species in the correct genus, yet the other characteristics are those of the members of the genus Spironoura and hence the present designation of the form as *Spironoura cryptobranchi* n. sp.

The type host is *Cryptobranchus allegheniensis*.

The type material is in the collection of Dr. Henry B. Ward, University of Illinois, Urbana, Illinois.

Zanclophorus cryptobranchi N. SP. [FIGS. 2-3]

Specimens belonging to the genus Zanclophorus were obtained from the rectum of *Cryptobranchus allegheniensis* and not only afford a new host record for the genus but also are the bases of an heretofore undescribed species. The worms are very small as compared to the type species from tortoises but show the characteristically well-defined three lips which are bordered internally by a chitinous band and which have the lateral margins of the adjoining lips supported by a horseshoe-shaped cuticular plate. This type of support may have arisen phylogenetically from the bar-type shown in the preceeding species which thus comes to serve as a possible connecting link in the undoubtedly close relationship of Spironoura and Zanclophorus. Each lip bears two prominent papillae. The vestibule is very prominent and is heavily cuticularized. The cylindrical esophagus ends in a double bulb, the posterior portion of which is greatly enlarged and provided with cutting plates. The cardia are also cuticularized. The tail of the male is without alae but shows five pairs of post-anal papillae, two of which are distinctly lateral in position and subtend an indistinct ridge which may

be a rudiment of alar flaps. There are also two pairs of ad-anal and three pairs of pre-anal papillae in addition to a single median pre-cloacal papillus. A pre-anal sucker and well-developed ventral muscle bands are also found. The spicules are sub-equal, slender, and slightly flanged. The accessory piece is large but only slightly chitinized. The tail of the female has a much longer taper than that of the male. The vulva opens in front of the posterior third of the body. The opposed uteri contain only 4- to 8-celled embryos, seemingly indicating the oviparous type of development. The majority of species in this genus have been described as being apparently viviparous.

The average measurements are as follows:

Male.—Body length, 7 mm.; greatest width, 0.3 mm.; length of vestibule, 0.095 to 0.1 mm.; length of esophagus and anterior bulb, 1.4 mm.; diameter of posterior bulb, 0.135 by 0.16 mm.; nerve-ring, 0.45 to 0.5 mm. from the lips; excretory pore, 0.75 mm. from the lips; cloacal-tail distance, 0.35 to 0.4 mm.; sucker-cloacal distance, 1.8 mm.; the spicules measure 0.75 mm., and the accessory piece measures 0.15 mm.

Female.—Body length, 8.5 to 9 mm.; width at vulva, 0.45 to 0.5 mm.; length of vestibule, 0.1 mm.; length of esophagus and anterior bulb, 1.5 mm.; diameter of posterior bulb, 0.15 by 0.175 mm.; nerve-ring, 0.45 to 0.5 mm. from the lips; excretory pore, 0.8 to 0.85 mm. from the lips; vulva-anus distance, 3.4 to 3.5 mm.; anus-tail distance, 0.7 mm., and the segmenting ova measure 0.06 by 0.075 mm. as they enter the ovejector.

The general characteristics are such that the form undoubtedly belongs to the genus Zanclophorus and to a new species. Because of the unusual new host the species is named *Zanclophorus cryptobranchi* n. sp.

The type host is *Cryptobranchus allegheniensis.*

The type material is in the collection of Dr. Henry B. Ward, University of Illinois, Urbana, Illinois.

Spiroxys allegheniensis n. sp. [figs 4-6]

Although typically parasites of tortoises and perhaps of watersnakes, the genus Spiroxys is represented by three males of a distinctly new species taken from the intestine of an immature specimen of *Cryptobranchus allegheniensis,* thus adding a caudate amphibian to the host list. This new species is materially larger than the type species of the genus, more nearly approximating the size of *S. constricta* (ex *Tropidonotus* sp.). The mouth parts show the typical pair of tri-lobed lateral lips, each thickened along the inner surface and provided with a single tooth on each median lobe. The mouth cavity leads into a short vestibule

which opens in turn into the anterior end of the muscular esophagus. The posterior end of the esophagus loses its muscular nature and becomes decidedly glandular in structure. The cuticula, particularly toward the posterior end, shows distinct longitudinal striations. The males possess well-developed caudal alae which are decidedly vesicular in structure in the pre-cloacal region. The alae are supported by nine pairs of pedunculate papillae of which the three large pairs are pre-anal and the six small pairs post-anal in position. Three of the post-anal pairs are lateral and three pairs are ventral in position. There are also two pairs of ventral sessile papillae, one pair in front of, and the other pair just behind the cloaca. The spicules are sub-equal, very slender, and rather short for the length of the worm. No traces of an accessory piece could be located.

The average measurements of the males are as follows:

Males.—Body length, 24 to 27 mm.; greatest width, 0.85 to 0.9 mm.; length of esophagus, 2.35 to 2.4 mm.; nerve-ring, 0.43 to 0.45 mm. from the lips; cervical papillae, 0.8 to 0.9 mm. from the lips; anus-tail distance, 0.36 to 0.37 mm.; length of spicules, 1.7 to 2 mm.

This material differs from *S. contorta* in size, in position of the alar papillae, in length of spicules, and in the possession of distinct longitudinal cuticular striations. It differs from *S. gangetica* and *S. annulata* in the armament of the lips and in the relative size of the spicules. It differs from the other known species of the genus, *S. constricta,* in mouth structure, in arrangement and number of alar papillae, in size of spicules, and in the possession of longitudinal cuticular striations. Because of these differentiating characteristics, as well as because of the decidedly different host, this new material, in spite of the absence of female specimens, is made the basis of a new species, *Spiroxys alleghenensis* n. sp.

The type host is *Cryptobranchus allegheniensis.*

The type material is in the collection of Dr. Henry B. Ward, University of Illinois, Urbana, Illinois.

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Explanation of Plate I

The scale represents: 0.05 mm. on figures 1 and 2; 0.3 mm. on 3, 4, 5 and 6.

Fig. 1.—*Spironoura cryptobranchi.* Anterior end of female. Dorsal aspect.

Fig. 2.—*Zanclophorus cryptobranchi.* Anterior end of female. Dorsal aspect.

Fig. 3.—*Zanclophorus cryptobranchi.* Posterior end of male. Lateral aspect.

Fig. 4.—*Spiroxys allegheniensis.* Anterior end of male. Lateral aspect.

Fig. 5.—*Spiroxys allegheniensis.* Anterior end of male. Dorsal aspect.

Fig. 6.—*Spiroxys allegheniensis.* Posterior end of male. Lateral aspect.

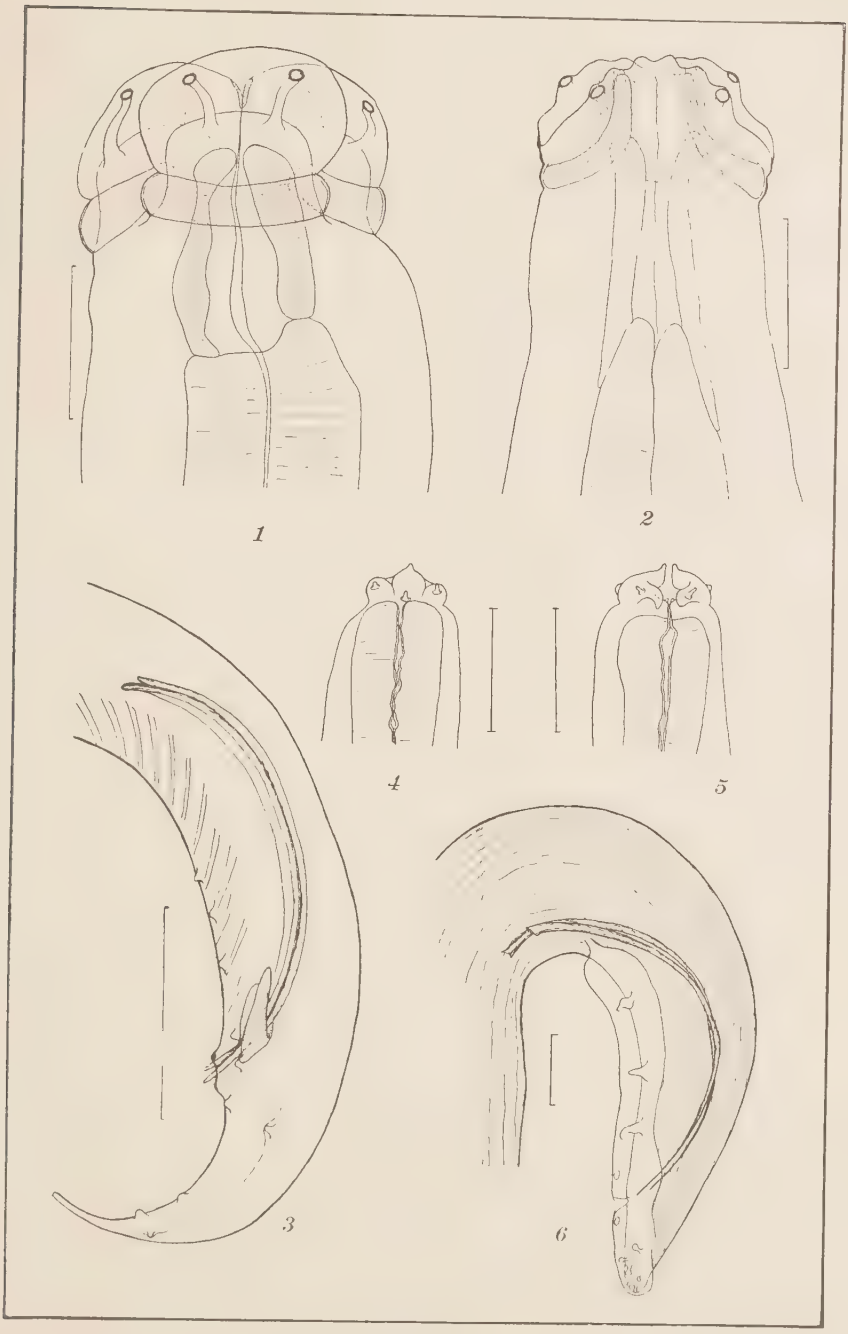

PLATE I

A NEW PRONOCEPHALID MONOSTOME FROM A FRESHWATER TURTLE *

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While making collections of turtle parasites in the summer of 1926, several specimens of a very interesting monostome were collected from the western painted terrapin, *Pseudemys elegans*. Seven specimens were taken from the intestine on June 26 of that year, the host having been collected the same day from Blue River, near Connorville, Johnston County, Oklahoma. No other collections are recorded, although several other specimens of the host have been autopsied at various times since from the same locality.

I have identified the parasites as belonging to the family Pronocephalidae Looss. This family is characteristically marine, with the great majority of the species described parasitic in the several species of marine turtles, and inhabiting various parts of the alimentary canal. So far as I have been able to determine from the literature, no previous records of freshwater species has been made. Anatomically the species presents several features of interest, especially pertaining to the excretory system. These features appear to justify a short description and discussion. Before proceeding further I wish to acknowledge the very helpful criticisms of Dr. Henry B. Ward, under whose direction this study has been made.

The following generic diagnosis, which must be considered as tentative since only the single species described in this paper is known, clearly separates the worms from any previously described genus of the family. Indeed, the description is at variance with certain family characteristics as given by Looss; these will be discussed in a later section.

Macravestibulum, NOV. GEN.

Pronocephalid worms of small size; the characteristic collar incomplete in the ventral region. Anterior part of the body highly muscular, posterior part with only thin musculature. The oral sucker small, subterminal. Ceca unbranched, passing dorsal to the testes and ending in a slightly enlarged portion just caudal to the posterior testis. The excretory pore very large, forming a transverse opening across the posterior extremity of the body, with diverging branches. This pore opens into a very large vestibular cavity, bifurcated into two lateral,

* Contribution from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 381.

somewhat variable and irregular, branches. The vestibule with part of the excretory bladder occupies between a fifth and a fourth of the total body length. Apparently without a connection between the vestibular cavity and the bladder. The pair of excretory trunks lie dorsal and lateral to the viscera and unite ventral to the esophagus in the anterior region of the body. Testes slightly asymmetrical, about one fifth of the body length from the posterior end. Cirrus sac large, thick, and curved, lying obliquely transverse to the long axis of the body. Ovary dorsal and anterior to the testes, and slightly displaced to the right side of the body. Vitellaria of heavy spherical follicles lying inside the ceca. Uterine coils transverse, between the ceca. Genital pore lateral, to the left side of the body, but inside the cecum, about one third of the total body length from the anterior extremity. Eggs with a heavy polar filament at each end.

Parasites of freshwater turtles. Type and only species the following:

Macravestibulum obtusicaudum NOV. SP.

Small, thick worms, the length in the seven specimens collected varying from 2.35 mm in the smallest to 2.95 mm in the largest. The breadth varies from 0.65 mm to 0.75 mm. The sides of the body are roughly parallel, the posterior extremity bluntly rounded, and the anterior extremity is encircled on the dorsal and lateral sides by the very characteristic "collar" of the Pronocephalid worms. Dorsally the body is strongly convex in fixed specimens; the venter is deeply concave in the anterior region, the depth decreasing posteriorly until a cross section of the body at near the caudal extremity shows an evenly rounded oval. The oral sucker is small, about 0.13 mm in diameter. The excretory pore is terminal and posterior, and very large, occupying over half of the total width of the body (Fig. 2). The genital pore is ventral, lateral (left), just inside the cecum, and about one third of the total body length from the anterior end.

The cuticula is thin and smooth; entirely unspined. Anteriorly the musculature is very heavy, with strong longitudinal and circular muscles in addition to the musculature of the collar. Posteriorly the musculature becomes thinner and weaker and is comparatively almost negligible posterior to the testes. The marked concavity of the venter in fixed specimens is probably due to the contraction of numerous dorso-ventral bundles traversing the parenchyme.

Digestive system. From the oral sucker a thin muscleless esophagus leads backward to a junction with the ceca 0.3 mm from the posterior edge of the sucker. Pharyngeal musculature entirely lacking. The ceca are smooth and unbranched, lying outside the visceral organs, and extend to a region just posterior to the right (and posterior) testis,

passing dorsal to the testes, and ending in a pair of pouchlike inflations which lie close together near the midline (Fig. 1).

The histology of the intestinal epithelium is worthy of notice. Large, semispherical nuclei are scattered thru the lining, closely pressed against the inner surface. There are no evident cell walls. The nuclei are darkly granular, with large rounded nucleoli, in their turn close to the nuclear wall toward the lumen of the intestine. The cytoplasmic portion is highly vacuolated. Separating the epithelium from the parenchymal material is a thin non-cellular membrane (Fig. 4).

The male reproductive organs: The testes are slightly asymmetrical, since the left one is situated slightly anterior and dorsal to the right one. In general they are spherical or slightly oval in shape, with but slight irregularities in outline. The posterior of the two is, in the specimens measured, slightly the larger, about 0.23 mm in largest diameter, while the anterior one varied from 0.198 to 0.23 mm. The vasa efferentia loop to the outside of the ceca and excretory tubes and join in a common vas deferens just anterior and ventral to the ovary. Anterior to the folds of the uterus is the conspicuous cirrus sac, lying almost transverse to the long axis of the body. Its length varies in the specimens measured from 0.45 to 0.55 mm by a thickness of 0.17 to 0.18 mm. It is rather acutely and characteristically curved (Fig. 1). Inside the sac, the pars prostatica may be made out as an inflated portion in the posterior end. The vesicula seminalis is outside the cirrus sac. The cells of the prostate gland fill the cirrus sac solidly. The cirrus is capable of but a relatively small amount of protraction since there is no coiled region, and the genital atrium is small.

The female reproductive system: The ovary lies dorsal and anterior to the testes, and slightly to the right of the midline. In ventral view it is more or less hidden by the testes, shell gland, and vitellaria. The entire shell gland complex lies directly ventral to the ovary, or slightly nearer the midline. The oviduct projects from the ventral surface of the ovary, and after traversing the compact shell gland widens almost immediately into the uterus. This latter organ proceeds forward in numerous transverse loops to the cirrus sac. There is a short narrow vaginal region. Extrusion of the cirrus evaginates the genital atrium to such an extent that it appears as if the vagina has a separate opening from the male pore. The situation of the vitellaria is unique in the Pronocephalids in that they lie inside the intestinal ceca. They form a pair of compact clusters of spherical follicles lying just anterior to the testes, and ventral and lateral to the ovaries, and projecting anteriorly from this region. Laurer's canal curves around the median surface of the ovary to the dorsal surface in the midline. Testes, ovary, shell gland complex, and vitellaria are crowded together in the third fourth of the body.

The uteri of all the specimens were filled with the characteristic Pronocephalid eggs. Each pole of an egg is equipped with a long stout filament or process, a continuation of the egg shell. The enlarged base of one of these filaments forms the egg cap or lid (Fig. 3).

The excretory pore is situated on the blunt posterior extremity, and is comparatively very large (Fig. 2). It forms a more or less transverse slit with short diverticula off on each side. It widens immediately into an extensive vestibular cavity, which is evidently an invagination of ectoderm, as the whole cavity is lined with cuticula continuous with the external body wall. The vestibule shortly branches into a pair of lateral chambers of irregular shape, which project forward to near the posterior borders of the testes. These branches are more or less flattened, concave on the median surface and convex laterally. Short diverticula may project from the lateral chambers (Fig. 6). The excretory bladder is contained in the pocket formed between the lateral branches, forming an irregular loop between them. Peculiarly, no opening between the excretory bladder and the vestibular cavity could be found, although satisfactory sections in two planes were obtained. Unless the excretory tubes be considered as a closed system, it must be assumed that passage of excretory material from the bladder to the vestibule takes place thru minute tubes or pores, which would be extremely unlikely, and certainly none could be traced out between the two organs even with an oil immersion lens. There is nothing in the appearance of the walls of the vestibular cavity to indicate that they are porous.

Lateral and posterior to the testes, the two trunks of the excretory canal send out a number of short lobate projections from the side walls. These are too short for true lateral branches and may be caused by excessive contraction of the whole body. Anteriorly the excretory canals unite ventral to the esophagus, and from their union a short median canal extends anteriorly to the region of the oral sucker (Fig. 1).

Type and paratype in the collection of Dr. Henry B. Ward, University of Illinois. Paratypes in the collection of the author.

DISCUSSION

I have no hesitation in placing this species in the Pronocephalidae although it disagrees in three points from the characterization published by Looss (1902). The first of these deals with the location of the excretory pore. In his diagnosis Looss says that the excretory pore is "dorsal, vom Leibesende mehr oder minder entfernt". The excretory pore in *Macravestibulum obtusicaudum* is exactly terminal and posterior. Since the distance of the excretory pore from the posterior extremity

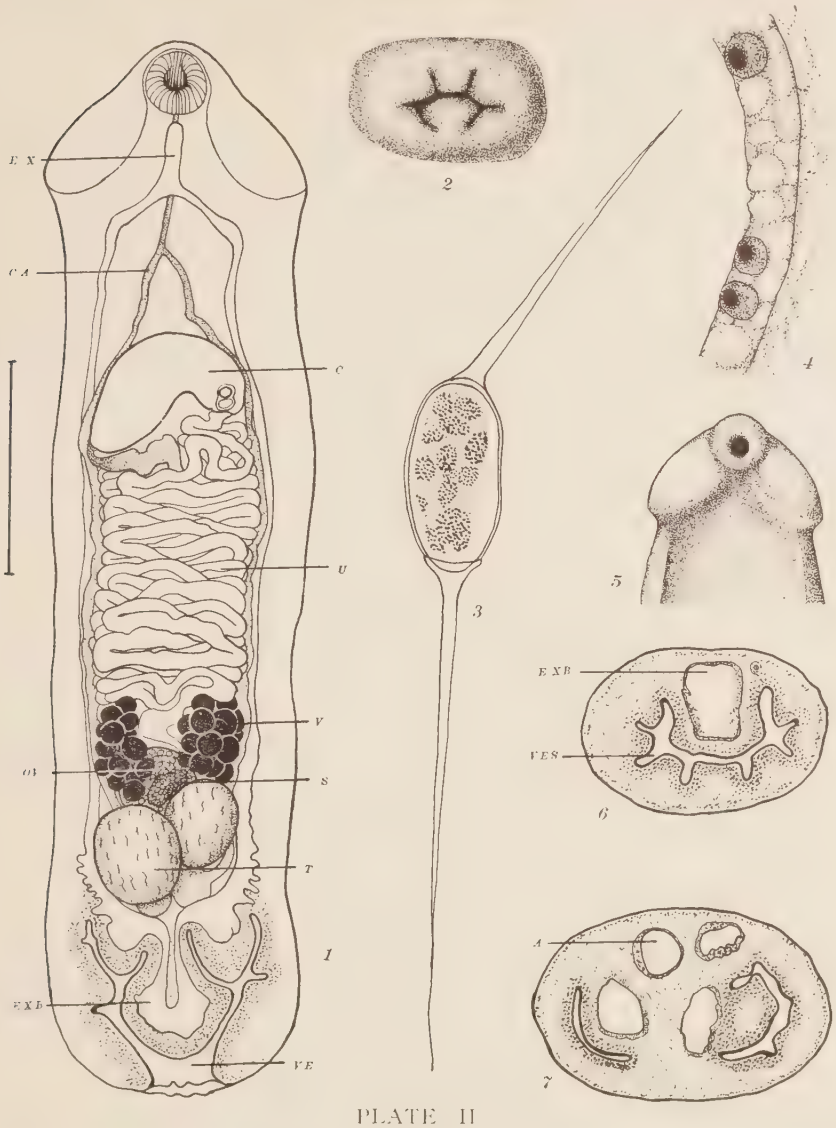

PLATE II

EXPLANATION OF PLATE II

Fig. 1.—Ventral view of toto mount. Camera lucida. Scale equals 0.5 mm.

Fig. 2.—Free hand drawing of the posterior extremity of an opaque specimen to show the excretory pore.

Fig. 3.—Uterine egg, showing filaments. Camera lucida.

Fig. 4.—Portion of the cecal wall. Camera lucida.

Fig. 5.—Freehand drawing of the anterior extremity of an opaque specimen, rather strongly contracted. Ventral view.

Fig. 6.—Transverse section through the excretory bladder, to show the relation to the vestibular cavity. Camera lucida.

Fig. 7.—Transverse section just posterior to the testes to show relation of ceca, excretory trunks, and vestibular cavity.

ABBREVIATIONS

C—Cirrus sac.
CA—Cecum.
EX—Excretory vesicle
EXB—Excretory bladder.
OV—Ovary.
S—Shell gland.
T—Testis.
U—Uterus.
V—Vitellaria.
VES—Vestibular cavity.

varies considerably in degree in the remainder of the genera of the family, this is not considered as an important variation.

Looss also described the shell gland complex as always occurring posteriorly to the ovary. In *M. obtusicaudum* the shell gland is ventral to the ovary and no part of the whole complex is caudal to the posterior margin. This is possibly due to the close crowding of the testes. The great development of the vestibule seems to have crowded the testes forward and to have turned the entire ovarian complex on edge. The author considers the shift hardly worthy of recognition as a family character.

Of perhaps more important nature is the fact that the vitellaria in *M. obtusicaudum* are inside the intestinal ceca. Again quoting Looss from his diagnosis of the family: "Dotterstöcke mässig entwickelt, in der hintern Körperhälfte und ausserhalb der Darmschenkel". On the other hand, if the general location of the glands in relation to the ovary and testes is considered, the shift in position is not considerable, especially when, as seen in side view, the ceca are located more dorsal than lateral to the vitellaria. In addition, the glands, if their position is not taken into consideration, are of distinctly Pronocephalid type, composed of large heavy follicles.

The remainder of the characters of the species agree so decidedly with those of the Pronocephalidae, that, as already stated, there seems to be no valid reason why it should not be included in the family. However, the differences noted preclude the possibility of including it in any of the existing genera. In addition, the enormous development of the vestibular cavity is so striking and unique, that it has no parallel in the family. There can hardly be any doubt that the structure is homologous to Looss' "Rippentrichter", although the general form of the organ is at great variance with any of the forms he described.

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RHIGONEMA NIGELLA SPEC. NOV., A NEMATODE AND ITS PLANT COMMENSAL, *ENTEROBRUS* SP? FROM THE MILLIPED*

LYELL J. THOMAS

In the summer of 1929 while at the University of Michigan Biological Station, Douglas Lake, Michigan, the attention of the writer was directed to some large nematodes together with some smaller forms taken from the intestine of the milliped *Parajulus dux*. This milliped according to Chamberlin (1914) is common in that region. The nematodes belonged to the family Oxyuridae and as they were large enough to use to advantage under low powers of the microscope and in addition were very transparent, the writer found them to be excellent material for introducing the anatomy of round worms to students. After opening numerous millipeds a number were found to contain a fungus growing normally as a commensal in the intestine of the millipeds and in many cases covering the cuticula of the nematodes so as to give them the appearance of woolley caterpillars. Some of the worms with the fungus adhering (Fig. 8) were sent to Professor Thaxter of Harvard who identified the fungus as a species of Enterobrus. In going through the literature on the subject the writer found that Leidy (1849) had described a similar relationship existing between oxyurids and a fungus, *Enterobrus elegans* from *Julius marginatus* Say. Similar forms were also described by d'Udekem (1859) from *Julius terrestris* and the large nematodes were erroneously referred to the Rhabditidae as *Rhabditis acuminatus*. Leidy (1849) likewise has referred similar large worms to still another family by designating them as *Ascaris infecta*.

The family Oxyuridae are parasitic worms with meromyarian musculature. As a rule their mouth parts are simple and the lips are usually inconspicuous. The esophagus usually has a pharynx and there is always a distinct posterior bulb containing three valves. The reproductive organs are simple. The ovaries are short and generally only a few large eggs are produced. The excretory pore is at about the level of the esophageal bulb. The caudal end of the female is always elongated and subulate.

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* Contribution from the University of Michigan Biological Station and the Zoological Laboratory of the University of Illinois No. 382.

Railliet and Henry (1916) refer those oxyurids in which the male has two equal spicules and an accessory piece to the subfamily Cosmocercinae. Baylis and Daubney (1926) expand this to include forms without an accessory piece such as Isakis and Odontogeton. They define the genus Isakis Lespés 1856, apparently from Skrjabin's (1914) description of *Isakis multipapillata* and he in turn seems to have followed Diesing (1861) who has grouped a number of unrelated species and genera under the term *Isacis*. Stiles and Hassall (1905) point out this orthographical error and the nomenclatorial difficulties developed in the literature. Christie and Cobb (1927) give many of these historical details and direct attention to the inadequate characterization of the Genus *Isakis* as defined by Lespés (1856), "Corpus fusiforme extremitate caudali longe subulatâ haud alatâ. Caput corpore continuum, truncatum. Os trilabiatum. Penis vagina spiculisque duobus aequalibus instructus. . . . Feminae apertura genitalis in corporis medio. Ovipara." Figures 11 and 12 of his type species plainly show an accessory piece, and from his figure 9 it is impossible to make out the condition of the uterus, whether it is single or double. In spite of this Baylis and Daubney (1926) have discarded a well defined group of oxyurids in the Genus Rhigonema of Cobb (1898) and have made it synonymous with *Isakis*.

The writer has found the worms of millipeds to be excellent teaching material as they eliminate the feeling of repulsion so often present when the large Ascarids are used as a type for the laboratory study of nematodes. Furthermore, there is no danger of a protein sensitization or reaction that sometimes occurs when using Ascaris. The transparency, size, and reactions of the live worms of millipeds make their study more desirable and incite interest on the part of the student. Millipeds are widely distributed and seem to be very generally infected and are easy to handle alive in the laboratory. Should they come into general use many new species are apt to be found as predicted by Christie and Cobb (1927).

To the Genus Rhigonema belong Leidy's (1849) *Ascaris infecta*, d'Udekem's (1859) *Rhabditis accuminatus*, *Isakis multipapillata* of Skrjabin (1914), and possibly *Isakis silvestrii* and *I. modiglianii* of Parona (1896). Walton's (1927) *Isakis robusta* may also prove to be a Rhigonema as the general description is the same although his figure and mention of a rudimentary accessory piece may remove it to an entirely different genus.

Rhigonema nigella spec. nov., conforms in general to other members of the genus in its essential features. The average length of adult

females is 6.468 mm. Other average measurements and form are, according to the formula of Cobb (1898), as follows:

$$\frac{0.5 \quad 3.1 \quad \overset{27}{7} \quad \overset{32.4}{\text{'57.'}} \quad 96.5}{2.1 \quad 2.8 \quad 3.1 \quad 4.6 \quad 1.3} = 6.468 \text{ mm.}$$

The average length of the adult male is 4.353 mm., with other average measurements and form according to this same formula.

$$\frac{0.7 \quad 3.2 \quad 7.6 \quad \overset{67.3}{\text{'M}} \quad 97.9}{2. \quad 2.8 \quad 3.2 \quad 4.6 \quad 2.3} = 4.353 \text{ mm.}$$

The clear colorless cuticula of both sexes is covered with exceedingly fine transverse striations and in addition minute retrorse bristles. The bristles fade out on one side laterally (Figs. 1, 4, 5, 12-18), disappear entirely midway of the body in the male and are continued more or less indistinctly on a lateral side in the female to the anal region. Three very insignificant but mobile lips are present and four cephalic papillae (Fig. 4). A shallow vestibule leads to a triquetrous pharynx within which are cutting plates with irregular denticulate edges hinged at their blunt corners. Skrjabin (1914, Fig. 59) illustrates a similar arrangement at the angles of the pharynx of *I. multipapillata*. At the base of the pharynx are three serrate-edged denticles. The esophagus is short and heavily muscular with a distinct pharyngeal swelling. Imbedded within it and parallel with the walls of the tripartite lumen are six, paired, rod-like structures (Figs. 1, 5) which are coarsely and transversely striated for about two-thirds their length. In cross section these rod-like structures appear granular and almost black with Mallory triple stain (Fig. 12) and extend from the central chitinized swellings of the lumen walls to their hinges. Similar structures are figured by d'Udekem (1859) for *Rhabditis acuminatus* and *R. macrocephalus*. Scrjabin (1914) in his figure of the male of *I. multipapillata* shows six rod-like structures coarsely striated for about half their length and apparently connecting with the corrugated valves. In *R. nigella* these same structures seem to be continuous with the large muscular, napiforme, cardiac bulb which contains three corrugated valves (Figs. 1, 15). The cardia are large and three-lipped. Large dark brown pigmented, saccate glands, nine in number (three double and three single) (Figs. 1, 14) surround the esophagus near the base of the pharynx.

The straight, tessellated intestine is distinctly set off by a constriction at the base of the cardiac bulb (Fig. 1) also at its juncture with the rectum in the female (Fig. 9). The lumen of the intestine (Fig. 17) is

irregularly pouched. Around the lumen but imbedded in the columnar cells of the intestinal wall are numerous yellowish brown refringent granules which give the intestine a somewhat darkened appearance, especially in its anterior third. The excretory system consists of a pronounced bilateral renette (Fig. 17) which empties by a common duct and pore ventrally at about the level of the corrugated valves (Fig. 16). An examination of serial sections through the intestine showed the presence of cellulose fragments and spores of a fungus within the lumen.

The reproductive systems are simple. In the female the vulva is slightly posterior to the middle of the body and has a retrorse, somewhat papilliforme, anterior lip. The reflexed ovaries (Fig. 11) empty in either case into large pear shaped spermathecae. The uterine branches, filled with numerous eggs, join a common glandular trunk (Figs. 11, 13). This in turn empties into a large thick, muscular walled, syringate bulb in the region of the vulva. This large muscular bulb usually contains several segmenting eggs which may be forced out through the chitinized lumen of the vagina. This large unpaired bulb-like structure is mentioned by Leidy (1849) for *Ascaris infecta* and is figured by d'Udekem (1859) for *R. macrocephalus*. The eggs are large, ellipsoidal, with thick smooth shells. They are segmenting when laid. Their average measurement is 67 by 44μ. The slightly arcuate spicules of the male are equal (Figs. 6, 8) and measure 0.427 mm. in length. They are irregularly channeled throughout their length and are hollow (Fig. 18). A large gland is situated at the base of each spicule. A single pre-anal papilla is found on the ventral surface of the male. In addition there are five pairs of pre-anal submedian papillae (Figs. 2, 8) and four pairs of post-anal papillae (Fig. 7). No bursa or accessory piece is present. The single reflexed testis is continuous with a series of enlargements and constrictions that make up the seminal vesicles and vas deferens. The vesicles are packed with large ovoid spermatozoa (Fig. 10) measuring on the average 5 by 9μ.

The musculature is meromyarian with twenty similar fields—five in each quadrant, although asymmetry is sometimes manifested in the appearance of six in a quadrant in some sections. Well developed rectal muscles are present in the female (Fig. 9) in addition to anal muscles that reflex the tail. In the male the tail is habitually reflexed.

Observations on the life history indicate that infection is probably direct. Numerous young forms in all stages of development were found in the small intestine of the milliped. In this same region the intestine was greatly constricted when heavily infected.

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Explanation of Plate III

All drawings were made with the aid of a camera lucida. The scale represents 0.05 mm. in figures 1, 3, 4, 5, 7, 10, 12, 13, 14, 15, 16 and 17; in 6, 8 and 9 it represents 0.20 mm. The same scale is used for figures 7 and 3, and for figures 12, 14, 15, 16 and 17.

Fig. 1.—Tangential view, head of live male, partially optical section, showing only two cephalic glands, nerve ring, rod-like structures of oesophagus, corrugated valves, cardiac bulb and cardia, connecting ducts of bilateral rennette, striations and spines of cuticula.

Fig. 2.—Pre-anal papilla, male, lateral view, showing sensory connections.

Fig. 3.—Segmenting egg from milliped feces.

Fig. 4.—Face view, male, showing lips, cephalic papillae, mouth opening, vestibule, cutting plates and dentacles of pharynx.

Fig. 5.—Head of female, toto mount, pressed out in glycerine to show two cephalic papillae and six rod-like structures of oesophagus.

Fig. 6.—Spicules of male dissected out.

Fig. 7.—Post-anal papillae, ventral view, male toto mount.

Fig. 8.—Posterior end of male, lateral view, toto mount, showing attachment of fungus, *Enterobrus sp?*, papillae, spicules, glands, intestine, vas deferens, cloaca, and musculature.

Fig. 9.—Posterior end of female showing, intestine, rectum, and muscles.

Fig. 10.—Spermatozoa from seminal vesicle.

Fig. 11.—Reproductive organs of female dissected out and drawn in detail on one side only to show, opposed ovaries and uteri, spermathecae, common glandular trunk of uteri, syringate bulb, and vagina.

Fig. 12.—Transverse section, female, through nerve ring.

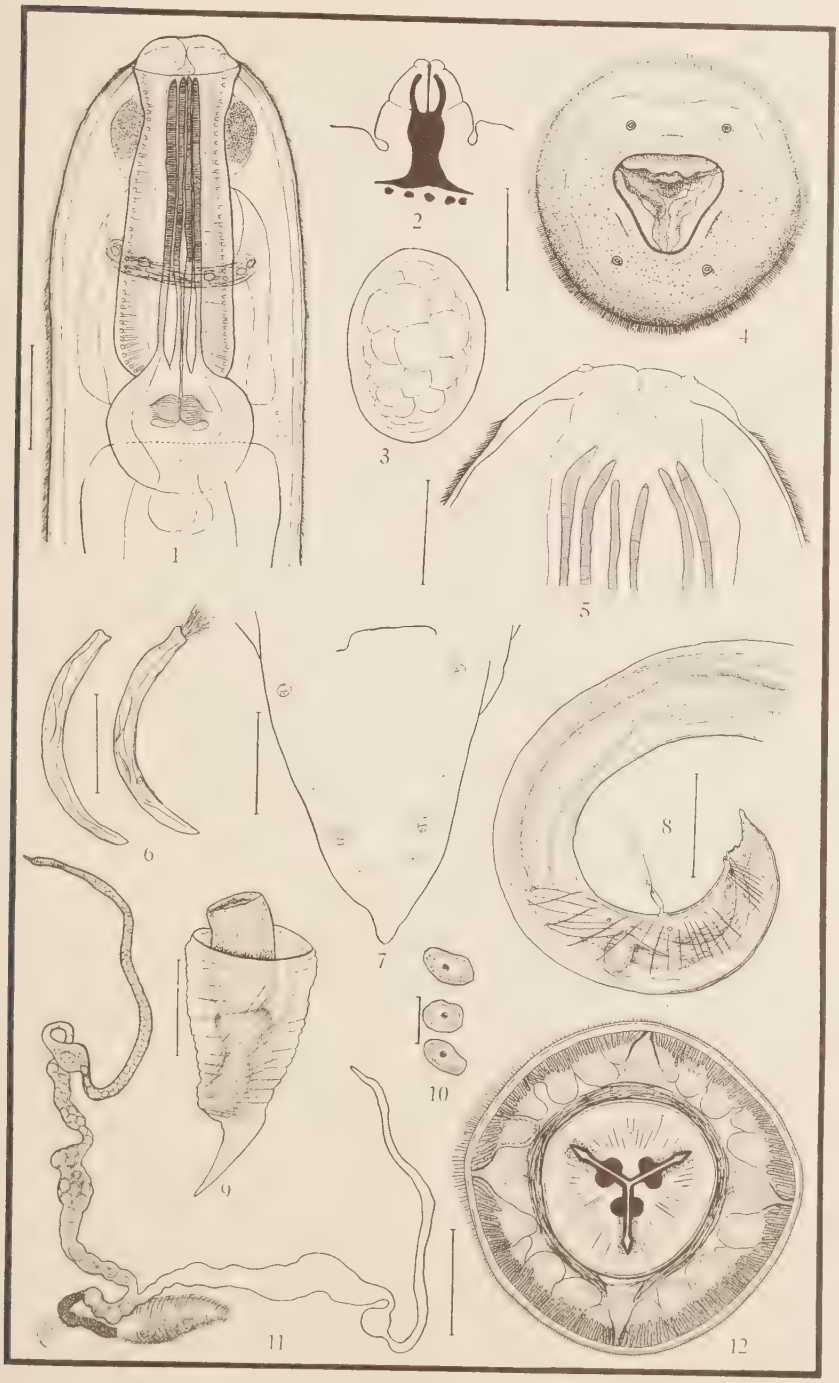

PLATE III

Explanation of Plate IV

Fig. 13.—Transverse section, female, through ovary, oviduct, uterus, common glandular trunk of uteri opening into muscular syringate bulb, intestine, muscle fields.

Fig. 14.—Transverse section, female, through cephalic glands, rod-like structures, muscle fields, and asymmetrical spines.

Fig. 15.—Transverse section, female, through corrugated valves.

Fig. 16.—Transverse section, female, through cardiac bulb, ducts of bilateral rennette and ventral pore.

Fig. 17.—Transverse section, female, through intestine a short distance behind the oesophagus and large glandular rennette in the lateral fields.

Fig. 18.—Transverse section, male, through cloaca, spicules, and muscles.

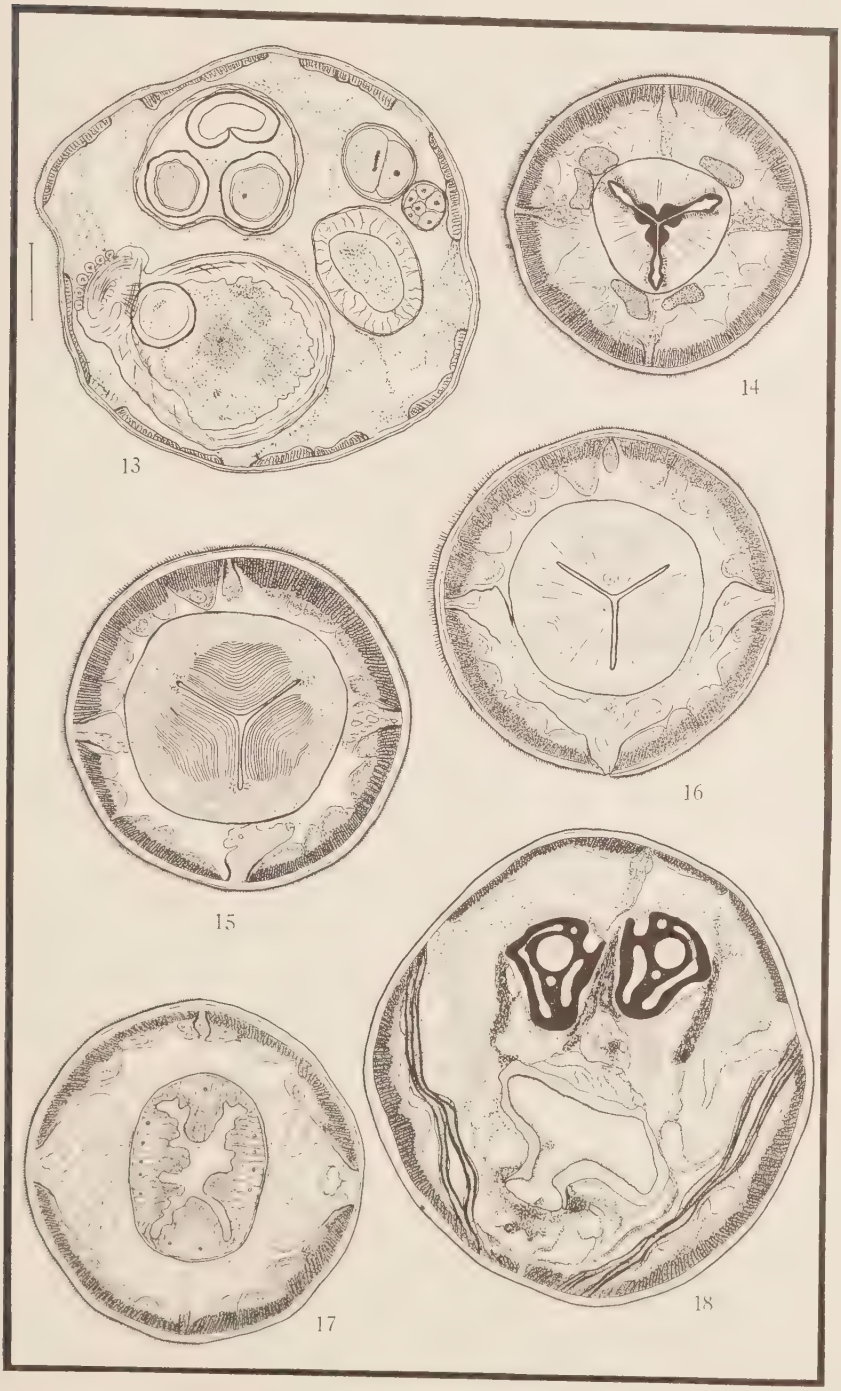

PLATE IV

THE STRUCTURE OF THE ESOPHAGUS IN THE TRICHUROIDEA

B. G. Chitwood

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The esophagus of members of the superfamily Trichuroidea, which is equivalent to the old family Trichotrachelidae, has been interpreted as of a structure different from that of other nematodes since the time of Eberth (1859). He figured the esophagus of *Trichocephalus dispar (Trichuris trichiura)* as being embedded within the body of a row of large cells, the *Zellenkörper*. Later, in 1863, he described the esophagus as consisting of an anterior free portion, and a longer posterior portion enclosed on three sides by the row of cells, the ventral surface only being free. The Zellenkörper was regarded by him as having a glandular function. Bastian (1866) is of the opinion that the esophagus of Trichocephalus, Trichina and Trichosoma (*Capillaria*) "may be considered a cylindrical organ with a central oval lumen, the ordinary transverse radiating muscle fibres being almost wholly replaced by the large nucleated cells with granular contents. Whether muscular fibres exist or not seems doubtful; I have never seen any, neither does Eberth speak of their presence. . . . The section of the lumen of *Trichocephalus affinis* seemed to me to have a somewhat triangular form."

Schneider (1866) goes into some detail on the esophagus of various Trichuroidea. He makes a difference between Trichocephalus and Trichosoma as compared with Trichina. In the first two, he divides the esophagus into two parts; the first part has a triradiate lumen; the second has a circular lumen and consists of a canal lying excentrically on the ventral side of the cell body. The esophagus in Trichina, however, according to him, consists only of the first portion and that which some have taken to be analogous to the cell body is the gut.

Leuckart (1866, 1876) probably has done the most work on this subject. He divided the esophagus into two parts, the first of which he called the *Munddarm*, the lumen of which he describes as having a typical triradiate shape. The second part he recognizes as being embedded in the side of the cell body and having a circular lumen. He states that the peritoneal membrane present in the anterior part of the esophagus envelops both the esophagus and the cell body, and for that reason he makes the suggestion that the latter might have been developed from the dorsal wall of the esophagus, though he states that he has no proof of such an occurrence.

Blanchard (1866) states that the esophagus in *Trichocephalus hominis* is very small and the muscles rudimentary. The second part is a remakable structure, consisting of a chitinous tube deprived of muscles and lodged in a sort of gutter on the ventral face of a longitudinal row of large cells which constitute the *corps cellulaire*. Thus it seems to be the consensus of opinions of earlier authors that the anterior part of the esophagus of trichurids does not differ greatly from the esophagus of other nematodes. Concerning the second part, they are somewhat at variance, but it seems to be settled that the tube continuous with the esophagus is embedded in the cell body. The lumen of this posterior part is considered as circular.

Hall (1916) stated that the esophagus in the Trichinelloidea (equivalent to Trichuroidea) is embedded in a chain of cells and that the lumen is triangular. He has come to this conclusion from a study of the literature. Dujardin (1845) characterized both *Trichosomum* and *Trichuris* as having a peculiar esophagus followed by an intestine composed of two parts, the cell body probably being the first part of the intestine.

Ward (1927) divides the nematodes into two major groups based on the structure of the esophagus as follows: "A type of radically different character is the capillary esophagus long known and exploited as a diagnostic feature in trichina and whipworm. It consists of a row of cells, pierced throughout the entire length by a delicate tube, of minute caliber. This tube has evidentally no power of changing form or caliber in functioning and is a sucking organ fitted to the ingestion of fluid nourishment exclusively. The various nematodes which possess such a capillary esophagus I have grouped together in a suborder Trichosyringata in contrast with those having a muscular esophagus which form the suborder, Myosyringata."

Rauther (1918) states that the esophagus of Trichosoma is embedded in the cell body, both being surrounded by a peritoneal membrane. The lumen varies in shape but is sometimes slightly triradiate. Yorke and Maplestone (1926) divide nematodes in a manner similar to that of Ward: "Oesophagus consisting of a narrow tube running through the centre of a row of single cells for most of its length . . . Trichuroidea Raillet 1916."

In a preliminary note (1930) I have pointed out that the earlier conceptions, such as those of Eberth (1863) and Leuckart (1876), were more nearly correct. Figures and a more complete description will be given in this paper. Since my preliminary note, Thomas (1924) has been kind enough to call to my attention a paper by himself on *Trichosomoides crassicauda*. His findings with regard to the structure of the esophagus are similar to my own.

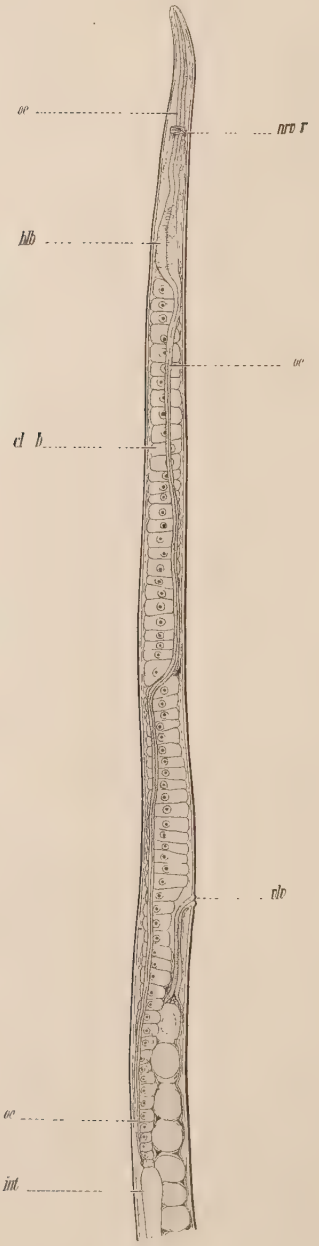
Müller (1929) questioned the view held by Rauther (1918) that the esophagus of Trichuris may act as an organ of nourishment and cited as his argument: How could it carry on such a function without contractile elements? He pointed out that though Heine (1900) recognized fibers from the anterior body running to the walls and acting as dilatores oesophagi, this has not been confirmed and in all probability he referred to the fibers of the basal membrane. Heine further stated that he believes the cell body, through some relation with the peculiar series of ventral glands acts as an organ of absorption and conducts food to the esophageal lumen, though he admitted that no mouth or duct had been seen penetrating the wall of the esophagus or in union with it. The question of the function of the cell body will probably remain in doubt for some time. The function proposed by Müller seems as yet quite doubtful.

It is of some interest to mention here that Fülleborn (1923) found that *Trichinella spiralis, Trichosomoides crassicauda,* and *Hepaticola hepatica* bear spears in the larval stage. On the basis of similarity he suggested the possible relationship of *Dorylaimus* with these forms.

ESOPHAGUS IN *Trichinella spiralis*

An examination of the adult *Trichinella spiralis* stained in cochineal, and mounted in glycerine jelly, shows that the esophagus itself is but slightly modified from that found in other nematodes. The anterior part near the head end is quite small, but seems to show a fibrous character. The nerve ring surrounds it as in other nematodes, and posteriorly ganglion cells may be seen on each side of it. The esophagus then becomes enlarged, forming a pseudo-bulb having no valves. Immediately anterior to the cell body it narrows abruptly and bends ventrally to the side of it. By focussing one may trace the esophageal tube through the remainder of the distance to the intestine. It may cross the cell body, in which case a deep groove is seen between the cells, it does not hold a constant position, but may be seen ventrally, subventrally, dorsally or subdorsally. It generally enters the intestine from a dorsal position. At the point of entrance it turns ventrally, or inward, in a short curve; bending between the cells of the cell body. The latter, though without lumen, appears to be an outgrowth of the intestine.

Sections of adults of the same nematodes stained with hematoxylin and eosin, show even greater similarity to the general conception of the nematode esophagus. The anterior region Munddarm of Leuckart (1876) is in general as he and Schneider (1866) have described it. The lumen is obviously triradiate. However, the walls seem to be of a muscular character, emphasized in the pseudo-bulb. Figures 1 to 3



Text figure *A*.—Anterior end of *Trichinella spiralis* in toto, showing the relation of the esophagus and cell body. × 270.

are views in this region. The first, being in the region of the nerve ring, shows processes from the dorsal, ventral and lateral chords extending inward and surrounding the nerve ring and ganglion cells. That which appears to be a duct of an esophageal gland, may be seen in each of the three muscular regions. A distinct peritoneal membrane surrounds the esophagus. In the swelling one sees three large nuclei of the form of gland nuclei found in other nematodes. The protoplasm surrounding them is granular.

In agreement with what is seen in the toto mount, sections show that the esophagus narrows very quickly and bends subventrally because of the presence of the cell body. At this point one sees no change in the form of the esophagus except that it becomes smaller. The membrane surrounding the esophagus maintains its identity. Another membrane surrounds the cell body but it may at times join that of the esophagus. In no place, however, does the esophagus lie next to the cell body with no intervening membrane. For that reason it is felt that the two have no developmental connection.

In the wall of the small tube one may distinguish radiating fibers which, though fine, give the impression of muscle fibers. Very small bodies have been seen in numerous instances, arranged in sets of three, which are believed to be nuclei, but being so small, it is impossible to say with certainty that they are nuclei. The lumen is triradiate. In no case has a section been seen in which the lumen could be interpreted as circular. The esophagus does not have a fixed relationship with the cell body, for it ranges between a subventral and a subdorsal position and only rarely is embedded even to half the depth of the esophageal diameter of the embedded sector.

Posterior to the vulva the esophagus maintains a subdorsal to dorsal position. In the last section showing it, the esophagus enlarges slightly and is embedded very deeply after making a distinct ventral bend, in the cell body. The next section shows a large tube with a flat lumen, in the middle of the last cell of the cell body. This tube is the anterior end of the intestine. No basal membrane is distinguishable between it and the cell body. The protoplasm of the intestine at this point does not differ very much from the protoplasm of the cell body. The cell body may be interpreted as an enormous outgrowth from the intestine, which has nearly filled the anterior portion of the nema, in which case it might be likened to a cecum without a lumen. With this explanation of the structure one can more readily understand the modification of the esophagus. Rauther (1918) and Müller (1929) have both given some attention to the function of the cell body and the esophagus. As a result of the writer's observations, he feels that the esophagus of

Trichinella spiralis is capable of functioning. However, the massive cell body probably has a function involving either the absorption or storage of food, though no physiological evidence for this assumption is offered. Cuticular pores were seen in the anterior region, but internal connections were not discovered.

ESOPHAGUS IN *Trichuris ovis* AND *T. vulpis*

After obtaining these results from observations on *Trichinella spiralis,* the writer was led to study in serial sections the esophagus of *Trichuris ovis* and *Trichuris vulpis.* In both species the anterior part of the esophagus, in front of the cell body, is similar to that found in *Trichinella spiralis,* that is, it consists of a thin anterior portion gradually enlarging to form an elongate bulb which is not provided with valves. Distinct large nuclei are seen in the middle of each sector. They are not at the same level, however. At that point where the cell body is first seen, the esophagus turns abruptly to one side and is embedded in the wall of the cell body but no protoplasmic connection is to be seen between them, there being a fine basal membrane around the esophagus.

The shape of the esophagus varies somewhat, for it is deeply embedded in the cell body, but its double wall never loses its identity. The muscular layer is less developed in some regions than others, and where it is less developed the lumen has fallen open more or less. Odd shapes may therefore be formed by slight pressure on that part of the cell body. Rauther (1918) has given excellent drawings of similar findings in several members of the Trichuridae. If one gives close attention to the inner wall of the esophagus, it is seen that the latter is fundamentally triradiate, joints being present on the three sides and slight projections indicating points where the apices of the sectors were originally. Probably the errors with regard to the structure of the esophagus in these forms are due to the fact that the cuticular lining of the esophagus has not been studied in sufficient detail.

Rauther is of the opinion that the cell body may have been derived from the dorsal part of the esophagus as a dorsal gland originally, though he states that he has never seen a connection between the two. His opinion is based partly on the fact that the basal membrane surrounds both the cell body and the esophagus. In Trichuris all that may be said regarding this is that there is also a separate basal membrane around the esophagus which usually shows a connection with the outer membrane, as would be expected if the organs were originally distinct but that gradually the esophagus is pressed into the cell body. At the posterior end the esophagus comes out of the cell body to some extent at the same level that two unicellular bodies appear; concerning the rela-

tionships of these unicellular bodies the writer is in doubt. They seem to be also connected with the intestine. They are surely the same organs remarked on by many of the earlier authors, some of whom called them intestinal ceca. Leuckart (1866) recognized that they were without lumen. Between these two organs and the cell body, the esophagus enlarges with a flat lumen forming an intestinal valve, a peculiar half-moon shaped structure around which the anterior part of the intestine is seen. The cell body projects 12 to 25μ posterior to the intestinal valve.

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Abbreviations Used

bas m—basal membrane
b cl—cell body
blb—pseudo-bulb
ch dsl—dorsal chord
ch lat—lateral chord
ch vnt—ventral chord
cl?—cell of unknown origin
cl b—cell body
cmb—embryo in uterus
int—intestine
ncl—nucleus
ncl cl b—nucleus of cell body
ncl oe—nucleus of oesophagus
nrv r—nerve ring
oe—oesophagus
ut—uterus
vlv—vulva
vlv int—oesophago-intestinal valve

Explanation of Plate V

Trichinella spiralis. All figures × 1870.

Fig. 1.—Cross section at the level of the nerve ring. The esophagus has three clear areas which may be gland ducts.

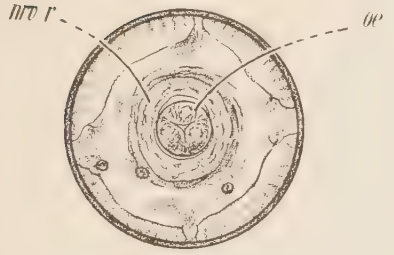
Fig. 2.—Cross section some distance posterior to figure 1. The section is placed upside down.

Fig. 3.—Cross section through region of pseudo-bulb.

Fig. 4.—Cross section at the beginning of the cell body.

Fig. 5.—Cross section in the posterior sixth of the esophagus.

Fig. 6.—Cross section through the bend as the esophagus is about to enter the intestine.



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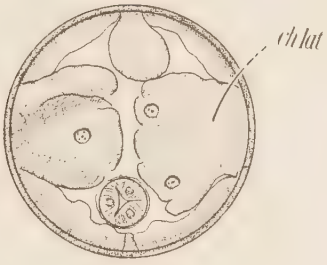

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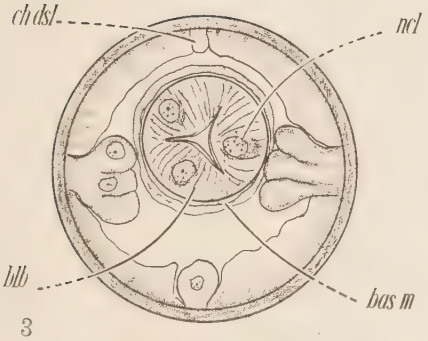

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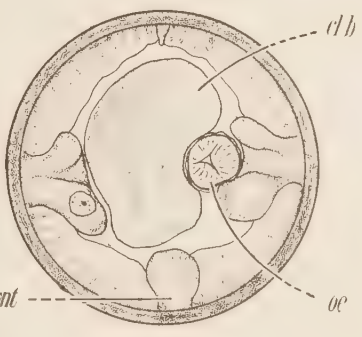

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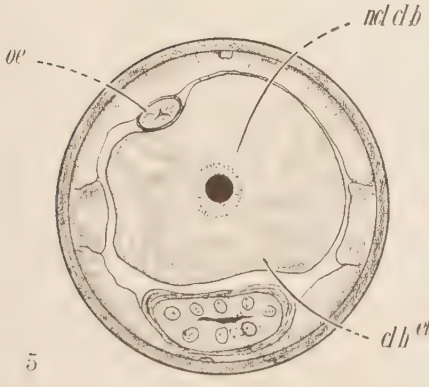

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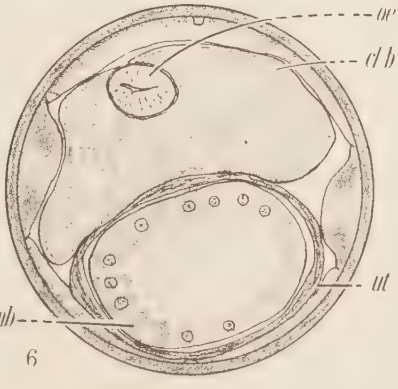

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PLATE V

Explanation of Plate VI

Trichuris ovis and *T. vulpis*

Fig. 1.—Cross section through region of pseudo-bulb in *Trichuris ovis*. × 650.

Fig. 2.—Cross section through region of cell body in *Trichuris ovis*. × 650.

Fig. 3.—Cross section through region anterior to oesophageal-intestinal junction in *Trichuris vulpis*. × 290.

Fig. 4.—Cross section of *Trichuris vulpis* 10μ posterior to figure 3. × 290.

Fig. 5.—Cross section of *Trichuris vulpis* through esophago-intestinal valve. × 290.

Fig. 6.—Cross section of cell body and esophagus of *Trichuris ovis*. × 660.

Fig. 7.—Cross section of esophagus of *Trichuris ovis* showing the opening of the lumen due to degeneration of the muscle fibers. It was embedded in the cell body as in figure 6. × 880.

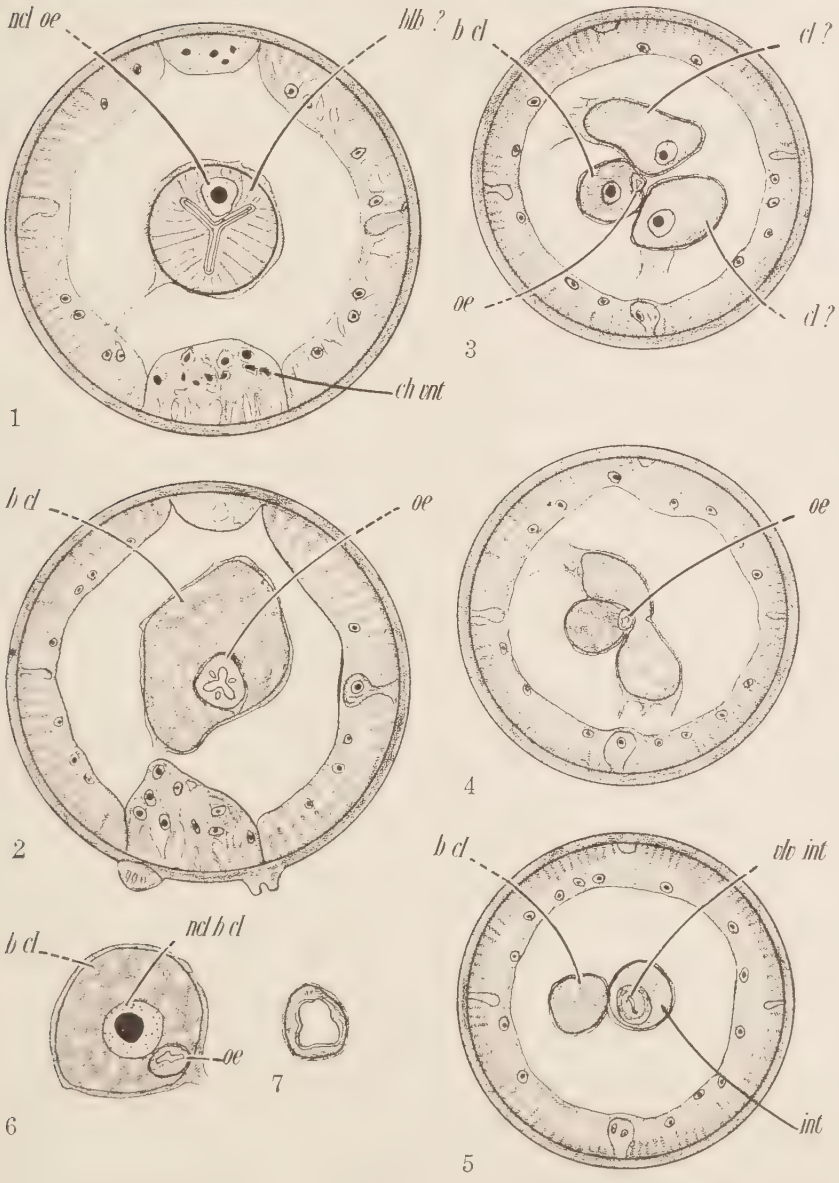
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PLATE VI

STUDIES ON THE STRUCTURE OF *CERCARIA INFRACAUDATA* N. Sp.*

MARGERY WASHBURN HORSFALL

The material for the study of the cercaria was gathered from snails (*Goniobasis livescens tricta*) found in the Salt Fork River at Homer Park, near Urbana, Ill. Approximately 1.2 per cent of the snails brought into the laboratory were infected with this species. The author is now carrying on experimental work to determine more of the life history of this form which is apparently undescribed. Sincere appreciation is here extended to Professor Henry B. Ward whose interest and cooperation have served as a stimulus for this study.

THE LIVING CERCARIA

Cercaria infracaudata is large and conspicuous, consequently it is easily seen when present in the aquarium. It is positively phototropic except in very strong light. Sudden changes in water temperature affect the number of cercariae which leave the snail and the time at which they leave it. Any constant temperature between the limits of 18 and 25 C. causes a fairly constant number of cercariae to leave the snail between certain hours, for example at 21 C., 10 to 15 cercariae leave the snail between 3:00 and 7:00 p. m. every day. When the temperature is continuously varied between 18 and 25 C., no cercariae appear and the snail soon dies. If the temperature is raised to 30 C. approximately every 60 hours, 20 to 25 cercariae will appear at one time, a larger number than under constant conditions. Thus by modifying the temperature, production of this cercaria may be controlled rather closely. Since only a few cercariae are given off each day, a control is necessary in order to have material on hand for study.

Cercaria infracaudata swims actively in the open water of the aquarium for approximately three hours after leaving the snail, then it either encysts, or drops to the bottom of the aquarium and crawls about a while; it dies within 24 hours. The reason why some cercariae encyst and others die was not determined. It was true in general that the first cercariae given off after a sudden temperature change encysted, while those leaving the snail later died. At the minimum temperature used in this experiment (18 C.), both the cercariae and the snails were more active than at higher temperatures.

* Contribution from the Zoological Laboratory of the University of Illinois, under the direction of Henry B. Ward, No. 383.

This cercaria has most of the features common to members of the monostome group. When no mention is made of a system, the author feels no discussion is necessary because of its similarity to the corresponding system found among other members of the group. The muscular tail and the latero-posterior locomotor organs are the only means of movement. The tail is attached by membranous dorsal and ventral connections to the mid-ventral region at the posterior end of the cercaria (Fig. 4). Mention of the tail attachment is omitted in the majority of descriptions of monostome cercariae. Cort describes *Cercaria urbanensis* which is very similar to *Cercaria infracaudata* as having its tail attached in the posterior mid-dorsal line. The latero-posterior locomotor organs are lined by epithelial cells and are not connected with any gland cells as are those of many of the monostome cercariae (Fig. 2 and 3). The body has the shape common to members of the monostome group being bluntly rounded anteriorly, long and narrow with parallel body walls when expanded, and round and ball-like when contracted. When expanded the body of the cercaria averages 1.25 mm. in length and 0.30 mm. in width. When contracted, the body averages 0.62 mm. in length and 0.56 mm. in width. Preserved mounted specimens have tails of approximately the same length as the body. The total length of the living animal is about 1.9 mm. whether the cercaria is contracted or expanded. If the body contracts the tail expands and vice-versa, so the total length remains fairly constant.

The anterior portion of the body is heavily pigmented especially in the region surrounding the two lateral eye spots and the median pigmented spot. No lens was seen in the median condensation of pigment which looked more like a ring of granules than like a true eye spot. In immature cercariae taken from the liver of the snail the median eye spot was not present; in place of it there were more scattered pigment granules in that region (Fig. 1). The granules extend backward in two lines on the dorsal and ventral surfaces outlining the paired dorsal and ventral nerve trunks. Many cystogenous glands are present throughout the body, imparting to the animal a characteristic greyish color.

The excretory system of *Cercaria infracaudata* is in general like that of other monostome cercariae but has some distinctive features which merit discussion here (Fig. 5). A large tube containing excretory granules forms a complete circuit along either side of the body from the region of the median eye spot to the excretory bladder and opens into the bladder in the anterior median line. The excretory bladder is very contractile and is constantly changing its shape. It is a U-shaped structure, the length of arms of the U depending upon its state of expansion. In immature cercariae an excretory tube extends from the

bladder through the tail and opens to the outside through two small lateral pores near the tip of the tail (Fig. 1). In mature cercariae this structure persists, but it is not functional and the bladder opens through the posterior-dorsal body surface between the dorsal and ventral attachments of the tail. A series of eight pair of flame cells connected by capillary tubes were observed in the mature form (Fig. 5). In the anterior third of the body four pair of flame cells were found, the largest and most conspicuous pair lying lateral to the oral sucker. In the posterior half of the body there are four additional pair of flame cells. The capillary tube connecting the four anterior pair and the four posterior pair runs for half the length of the body on the surface of the excretory tube containing the granules.

The nervous system is made up of four longitudinal trunks, two near the dorsal surface and two near the ventral surface (Fig. 6). The anterior ends of the dorsal trunks and those of the ventral trunks are connected by an esophageal commissure, just posterior to the median eye spot. The dorsal and ventral nerve trunks have four lateral connections with each other. The dorsal trunks join at the base of the tail near the posterior end of the body and innervate the tail. A long line of large nerve cells and their processes may be traced through the length of the tail. The ventral trunks do not join but go directly to the latero-posterior locomotor organs and innervate their central extensible portions (Fig. 2 and 3). In the posterior portion of both the dorsal and ventral trunks, there are several small enlargements of the nerve trunk from which no nerve processes could be seen to extend.

The genital system is well developed and shows the beginnings of the mature organs (Fig. 6). An ovarian cluster lies in the dorso-median body region near the ends of the intestinal ceca. Two vitelline masses of follicles lie antero-ventral one on either side of the ovary. Each is made up of nine follicles, five in the series nearer the lateral body wall and four in the series nearer the median line. These two masses each connect with the ovary by a thin inconspicuous vitelline duct. The uterus is not an open tube, but is composed of a convoluted series of deeply staining cells extending antero-dorsad for one third the length of the body. This line of cells turns ventrad one third the length of the body from the anterior end and joins the vagina which is continuous with the genital opening. A pair of large testes lies lateral and posterior to the ovarian mass. No vas deferens was observed leading from the testes to the cirrus pouch which is anterior to and continuous with the vagina at the genital aperture. The cirrus pouch connects with the uterus by a short line of deeply staining cells similar to those of the

uterus. It is possible that the uterus and the vas deferens are in close contact with each other from the connection of the cirrus pouch and the uterus to the testes.

THE REDIA OF THIS SPECIES

Rediae were found in the liver of the snail, but no sporocysts were observed (Fig. 7). The rediae are simple sac-like structures 0.52 to 1.09 mm. in length and 0.12 to 0.22 mm. in width. The cavity of the oral sucker opens into a short esophagus which leads into a large sac-like intestine, two thirds the length of the body. There are no foot-like projections or constrictions on the body of the rediae. Near the posterior end of the body numerous germ balls are formed. Two to eight cercariae of increasing size and maturity are found from the posterior germ ball region anteriorly. The cercariae leave the rediae before they are mature and go into the liver of the snail. Those found in the liver of the snail had two lateral eye spots and a functional excretory tube extending down through the tail (Fig. 1). This condition is never found in the mature cercariae that leave the snail. Within the liver of the snail the cercariae undergo some development; the median eye spot forms and the excretory tube of the tail stops functioning. By the time *Cercaria infracaudata* leaves the liver, the two openings of this excretory tube have closed and the tube ends blindly in a swollen bifurcation.

DISCUSSION

The general classification of monostome cercariae as outlined by Cort and Faust is based primarily on the presence of two or three eye spots. It is not certain whether *Cercaria infracaudata* would be classified as a binoculate or a trioculate monostome cercaria, because Cort and Faust do not describe the structure of the median pigmented spot. For the present purposes *Cercaria infracaudata* is regarded as a trioculate monostome cercaria. *C. konadensis* Faust 1917, *C. hemispheroides* Faust 1924, *C. fulvoculata* Cawston 1911 and *C. lophocerca* Filippi 1875 can be separated from my species by the presence of two eye spots. *C. plana* Faust 1922 and *C. trabeculata* Faust 1924 are spinose while this cercaria is smooth. *C. aurita* Faust 1918 as described has no excretory granules. *C. zostera* Sinitizin 1911 is more fertile than *Cercaria infracaudata* because each redia contains twenty or more young cercariae. *C. imbricata* Looss 1896 has a functional excretory system in the tail. Sewell describes *C. XI* Sewell 1922 from India as having no cross connections between the excretory tubes containing the granules. *C. luciana* Leidy 1877 is only briefly described, but the presence of a sporocyst, if it is a true sporocyst, or the structure and color if it is a redia would

separate *C. luciana* and *Cercaria infracaudata*. *C. robusta* Faust 1918 has gland cells which pour their secretions into the posterior locomotor organs.

The descriptions of the above mentioned cercariae indicate that they are in the main easily distinguishable from the cercaria described here. *C. urbanensis* Cort 1914 is the only exception to this statement. This species averages 0.3 mm. shorter than *Cercaria infracaudata;* it has six pairs of gland cells in the tail, all of which this cercaria lacks, and the tail is attached dorsally. Except for these three differences, the two forms might be considered identical.

SUMMARY

Cercaria infracaudata is a new monostome larval trematode whose parthenita is a redia. The internal morphology is generally typical of that found among the monostome cercariae, but from these the species described here can easily be distinguished. The complete morphology, the new *Cercaria* and the partial morphology of its rediae have been described. Investigations concerning the life history of this interesting form are in progress.

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Abbreviations Used

c—cuticular portion of body wall.
e—extensible portion of body wall.
n—pigment granules along nerve trunk.
d—dorsal nerve trunk.
l—lateral nerve connection between dorsal and ventral nerve trunks.
v—ventral nerve trunk.

Explanation of Plate VII

Figures 1 and 4 were made with the aid of a camera lucida; the remainder were made from living material except the genital system in figure 5. Scale lines represent 0.1 mm. in all figures.

Fig. 1.—Immature cercaria taken from the liver of snail showing pigmentation and excretory bladder with excretory tube.

Fig. 2.—Posterior locomotor organ expanded.

Fig. 3.—Posterior locomotor organ contracted.

Fig. 4.—Lateral view of cercaria showing genital system and tail on ventral surface.

Fig. 5.—Mature cercaria with tail, showing excretory and genital systems.

Fig. 6.—Mature cercaria after losing tail, showing digestive and nervous systems.

Fig. 7.—Redia containing immature cercaria.

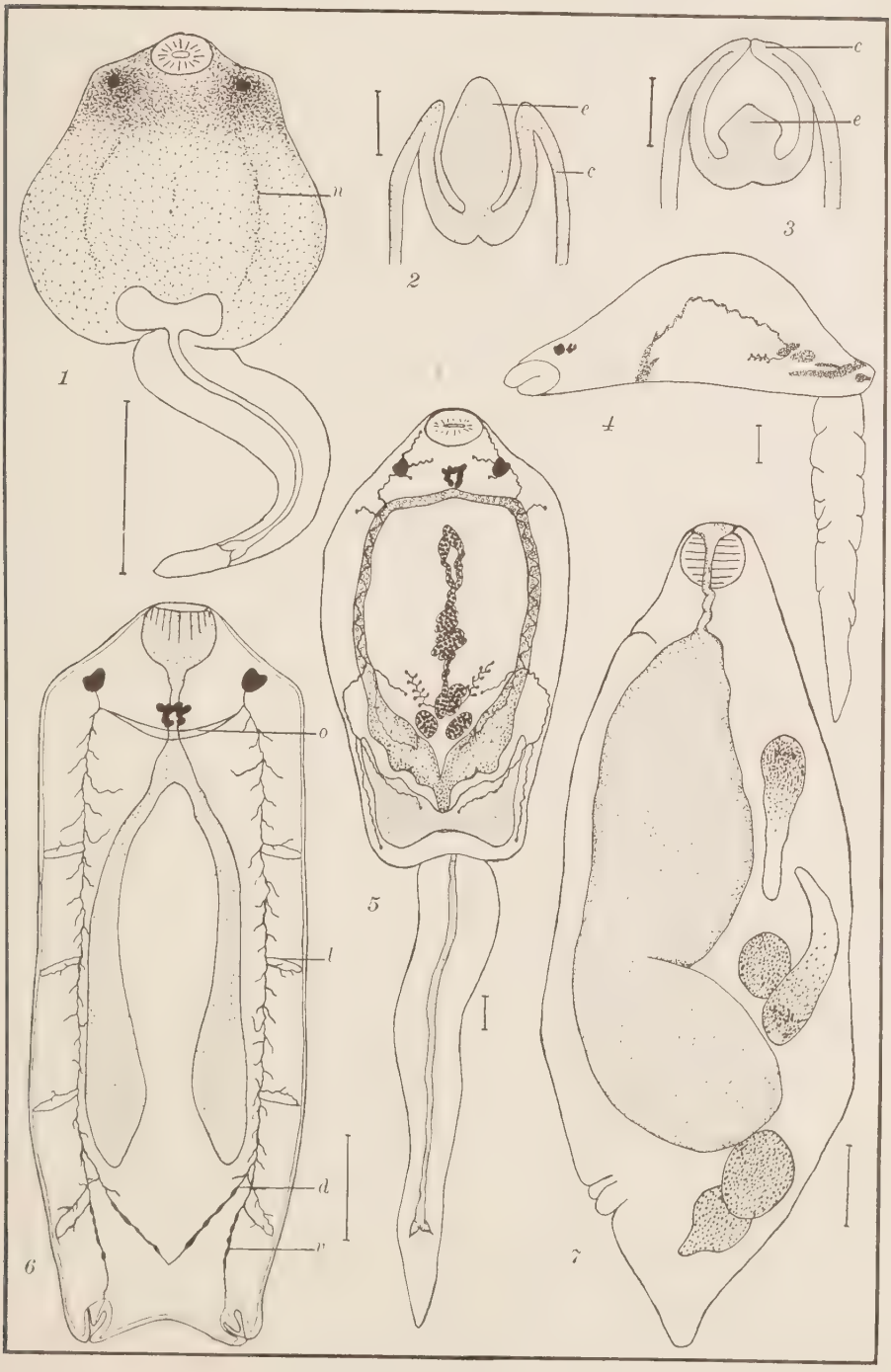


PLATE VII

A NEW HEDRURIS FROM *DIEMYCTYLUS VIRIDESCENS* *

A. C. Walton

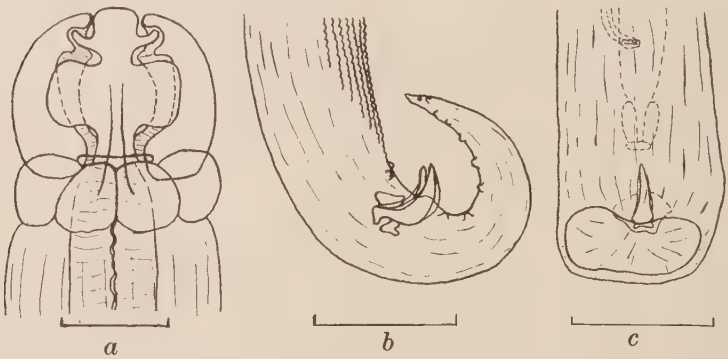
Chandler (1919) published a note on the known species of Hedruris, indicating three: *H. androphora* Nitzsch from European Amphibians, *H. siredonis* Baird from the axolotl and *Notophthalmus torosus,* and *H. armata* Perrier from turtles. He indicates the belief that the *Synplecta pendula* of Leidy 1851 is probably *H. armata.* Leidy in 1886, expressed the view that *S. pendula* was probably *Hedruris androphora.* Yorke and Maplestone (1926) list the above three species and in addition mention *H. hipsirhinae* Chatin from *Hipsirhina bocourti, H. orestiae* Moniez from *Orestias* sp., and *H. squamata* Linstow from turtles. Walton (1927) found on examination of the original Leidy material that although it undoubtedly belonged to the genus Hedruris it was neither *H. androphora* nor *H. armata,* but identical with *H. squamata. Synplecta pendula* Leidy 1851 therefore becomes *Hedruris pendula* (Leidy 1851) and being the same as the *H. squamata* of Linstow 1909, the later name falls into synonymy. With the exception of the material used by Chandler (*H. siredonis*), examples of this genus apparently are not often observed and possibly are actually rare. Such seems to be the case among the amphibian hosts, as examination of a large number of various host forms has resulted in many examples of *H. siredonis* Baird being found and but only one case in which the parasites belonged to another species of Hedruris. This particular material was obtained on loan from Dr. Henry B. Ward of the University of Illinois and consisted of both male and female examples of an apparently hitherto undescribed species of Hedruris which had been taken from the stomach wall of an example of *Diemyctylus viridescens* that had been captured in North Carolina.

Of the described species of the genus Hedruris, the present material comes closest to *H. androphora* in general size, in arrangement of the internal organs, and in relative proportions, but stands unique in that it possesses distinct longitudinal striations in both sexes in addition to transverse markings. This characteristic, together with other less outstanding features, indicates the presence of a new species of Hedruris.

The mouth shows four distinct lips, two median and two lateral. The lateral lips are thick but cuticular, and show very distinct anterior prong-like extensions and equally distinct posterior flap-like projections. Base and apex of the lips are approximately of the same diameter. The median

* Contribution from the Biological Laboratories of Knox College, No. 35.

lips are likewise thickened and cuticular, showing the irregular truncated triangular shape characteristic of the genus. Very distinct post-labial cuticular swellings are present. The cylindrical vestibule opens through a simple unmodified chitinous ring into the long, slender esophagus. In all other species of the genus the esophageal chitinous collar is variously draped in festoons. The presence of cervical papillae seem to place this material close to *H. armata,* other members of the genus apparently lacking such structures. The tail of the male is permanently spiralled. The pre-cloacal region shows 15 to 18 rows of tubercles. There is one pair of pre-cloacal sessile papillae. Instead of the typical six pairs of post-cloacal sessile papillae there are nine such pairs. In this respect this form resembles *H. siredonis.* The sub-equal spicules are short, thick, and sickle-shaped; showing a narrow dorsal flange along the



EXPLANATION FOR TEXT-FIGURE

Text-figure.—*a.* Anterior end of male, lateral view. *b.* Posterior end of male, lateral view. *c.* Posterior end of female, dorsal view. In *a* scale equals 0.05 mm., in *b* and *c* it equals 0.25 mm.

posterior border and a similar ventral flange along the anterior border. The accessory piece is well chitinized. The posterior end of the female is bent sharply dorsad at about the level of the anus and terminates in a retractile sucker-like invagination which is armed by a definitely chitinized hook capable of being exerted or withdrawn within a pouch-like depression in the ventral wall of the sucker. The vulva is immediately anterior to the anus. The eggs contain well-developed embryos at deposition; this form being oviparous. The eggs are very indistinctly mammillated, have double terminal opercular plugs, and show lateral wing-like flaps.

The average measurements for this species are as follows:

Male.—Body length, 3.8 to 4.5 mm.; greatest width, 0.16 mm.; lip-nerve ring distance, 0.2 mm.; lip-excretory pore distance, 0.265

mm.; lip-cervical papillae distance, 0.16 mm.; length of esophagus, 0.95 mm.; cloaca-tail distance, 0.365 mm.; length of spicules, 0.15 mm.; length of accessory piece, 0.066 mm.

Female.—Body length, 4 to 5 mm.; greatest width, 0.33 mm.; lip-nerve ring distance, 0.265 mm.; lip-excretory pore distance, 0.335 mm.; lip-cervical papillae distance, 0.185 mm.; length of esophagus, 1 mm.; anus-tail distance, 0.3 mm.; vulva-anus distance, 0.365 mm.; size of eggs, 0.02 by 0.04 mm.; length of caudal spike, 0.13 mm.

This material differs from the other species in (1) the presence of longitudinal as well as transverse cuticular striations in both sexes, (2) in the individual type of the lip formation, (3) in the relative position of the anus and vulva, (4) in the length of the spicules, (5) in the size of the eggs, and (6) in the actual size of the mature specimens. Because of its extremely short body, this form is named *Hedruris brevis* n. sp.

Type host.—*Diemyctylus viridescens.*

Type locality.—North Carolina.

Type specimens.—No. 18.42, Ward Collection, University of Illinois, Urbana, Ill.

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SOCIETY PROCEEDINGS

HELMINTHOLOGICAL SOCIETY OF WASHINGTON

One Hundred Twenty-Seventh to One Hundred Thirtieth Meetings

The one hundred twenty-seventh meeting was held February 19, 1930. Motion pictures dealing with problems in parasitology were exhibited.

The one hundred twenty-eighth meeting was held March 15, 1930.

Captain C. S. Butler commented on recent investigation of yaws and the evidence which this investigation furnished, pointing toward the probable identity of *Treponema pertenue* with *T. pallidium.*

Mr. B. G. Chitwood presented a series of lantern slides illustrating comparative nematode morphology.

Dr. N. A. Cobb reported losses in the rearing of slash pine (*Pinus caribaea*) seedlings in Florida resulting from nema injuries. Out of twelve species found associated with the roots of seedlings, at least three are parasites.

Dr. W. W. Cort, discussing recent Ascaris investigation, pointed out that his work in China did not appear to bear out the belief that adults are less susceptible to infection than children.

Dr. G. Dikmans presented two notes as follows: (1) *Capillaria brevipes* in cattle.—In U. S. Bureau of Plant Industry Bulletin 127, Ransom lists *Capillaria brevipes* from the sheep and *Capillaria longipes* from the sheep and the antelope. In 1922 capillarids were reported by Dikmans from cattle in Louisiana. No specific determination was attempted because no male was found among the specimens collected. Recently a section of small intestine from a calf in Virginia was submitted for examination. Among the nematodes collected there were found three specimens of Capillaria, two females and one male. On the basis of a study of this material a diagnosis of *Capillaria brevipes* has been made.

(2) An Oxyurid from the Deer.—Through the courtesy of the Bureau of Biological Survey, the viscera of a deer killed at Boise, Idaho, were submitted to the Zoological Division for examination. On examining the contents of the cecum and colon there were found about 40 specimens of a nematode which on examination proved to be an oxyurid. Only females were found. The only other record of oxyurids in ruminants in this country are those reported by Schwartz who described *Scrjabinema ovis* from the goat on the basis of some specimens sent to the laboratory by Dr. H. M. Martin of the University of Nebraska.

Miss Myrna Jones presented the following report, submitted by Dr. L. A. Spindler, on the occurrence of the swine kidney worm in a yearling calf.—On January 22, 1930, Mr. E. R. King of the meat inspection force at Moultrie, Georgia, turned over to me the kidneys of a one year old calf slaughtered under his inspection. In this material an immature kidneyworm, *Stephanurus dentatus,* was found near one of the kidneys, about 15 mm. from the renal lymph gland. The worm had been cut during inspection and only the anterior portion was recovered. This measured 12.4 mm. in length by 0.93 mm. in width at the widest place. The parasite had apparently been alive at the time of inspection as no evidence of disintegration was observed. No other specimens were found.

Dr. E. W. Price presented the following: (1) A note on *Paramphistomum aspidonectes* MacCallum, 1917.—An examination of what appear to be the specimens upon which the original description of *P. aspidonectes* was based shows that this trematode is a monostome apparently related to members of the Pronocephalidae. Fukui (1929), in his revision of the amphistomes, places this species in a new genus, *Opisthoporus,* for which he erects the family Opisthoporidae. A redescription of the species will be given elsewhere.

(2) Dr. Price exhibited specimens of *Dicrocoelium dendriticum,* recently sent to the Bureau of Animal Industry for identification by Dr. R. L. Conklin and Mr. Alexander D. Baker of MacDonald College, Quebec. (See paper in this issue of the JOURNAL by R. L. Conklin and A. D. Baker, page 18.)

Miss Myrna Jones presented a preliminary note on the life history of *Metroliasthes lucida,* a tapeworm of the turkey.—Gravid segments of *M. lucida* were fed to a number of grasshoppers, *Melanoplus differentialis* and *Melanoplus sp.* Two of the grasshoppers were caught out of doors as adults; all others were laboratory bred. In eight grasshoppers cysticercoids of various ages have been recovered. The scolecies are unarmed, when developed, and the embryonic hooks, when present, are equal in length to those of *M. lucida* onchospheres. The numbers found varied from one or two to as many as twenty. Cysts, apparently mature, were fed to two chicks and one quail but no tapeworms were found upon postmortem examination. An adult turkey has recently been fed with cysts, but has not yet been examined.

Dr. G. Steiner called attention to a species of Enchelidium and discussed the organs of light perception in nemas.

Dr. R. Wetzel reported some observations on the development of eggs and free-living larvae of *Strongylus equinus* Mueller.—In tests conducted with *Strongylus equinus* at constant temperatures, the time required for the embryonic development of the eggs was about the same as the span of life of the first stage larvae, while the span of life of the second stage larvae was as long as these preceding stages combined. The lowest temperature at which third stage larvae were developed in about 350 hours was at 12 to 13° C., but it should be mentioned that only about 10 per cent of the hatched larvae became mature. The highest temperature under which infective larvae developed was 39° C., but only a low percentage developed at this temperature. The highest percentage of infective larvae was obtained between 23 and 30° C. A rather high percentage of eggs and first and second stage larvae tolerated freezing temperatures near 0° C. for several hours under laboratory conditions as well as in the open, while most of the infective larvae withstood longer and repeated freezing even at lower temperatures.

Under natural conditions the development is accelerated during the day with its rising temperatures, while it is retarded or even stopped for hours during the night with its falling temperatures. The lowered temperatures at night result in a lengthening of the time necessary for development, especially in the spring and fall, as is shown by the thermograph cards from experiments in the open during the different seasons of the year. By analysing the statistics of the last thirty years on the average daily maximum and minimum temperatures and the number of days when freezing and ice formation occurred, at Hanover, Germany, it was found that development of infective larvae in the open seems possible from about the middle of March until about the middle of November during a normal year.

The one hundred twenty-ninth meeting was held April 19, 1930.

Dr. C. W. Stiles was elected as Society's representative to the forthcoming Zoological Congress at Padua.

Mr. John Bozevich gave a preliminary report on the viability and migration of *Haemonchus contortus* larvae under various conditions of weather and soil.—Boxes of clay, sand, and loam soil, containing *Haemonchus contortus* larvae, were placed outside of windows with northern and southern exposures on the second floor of the Department of Agriculture building. The larvae were thus exposed to natural weather conditions and were found to be still alive and very active when placed in water, after a period of seven months. Present indications are that the larvae in the southern exposure window are dying faster than those in the northern exposure window. This may be due to the abundance of sunlight in the southern exposure window which evaporates the moisture from the soil, thus producing an unfavorable environment for the larvae, or to the stimulation of larvae by exposure to greater extremes of light and temperature, thus exhausting the food reserve, or both. In the northern window, the larvae migrated a distance of three inches in the sand soil, one and one-half inches in the loam soil, and one

inch in the clay soil. Migration in the clay soil, and to some degree in the loam soil, was hindered by the formation of a crust which enclosed the larvae. In the southern window, the migration in all types of soil was less than in the northern. It was found that wind and rain transported the larvae from place to place. When eggs were refrigerated at —2.2° C. in cultures of sand, loam and clay, it was found that the eggs were killed in 6 hours in the sand soil, 6½ to 7 hours in the loam soil, and 8 hours in the clay soil. In similar cultures, refrigeration of first stage larvae at 0° C. for 28 hours killed all larvae. Second stage larvae submitted for one week to a temperature of 0° C. were found to be dead upon examination.

Dr. N. R. Stoll reported that recent experiments with goats indicate that this host also acquires a resistance to *Haemonchus contortus* similar to that acquired by sheep (Jour. Parasit., 15:217 and 292).

Dr. D. Sinitsin presented a note on the life history of *Fasciola magna.* (To be published elsewhere.)

Mrs. L. Sinitsin presented a note on the Lymnaeidae concerned in the distribution of liver-fluke disease. The environmental factors concerned in the propagation of these snails were discussed. Specimens of snails which serve as intermediate hosts for liver flukes of sheep and cattle in the United States were exhibited.

The one hundred thirtieth meeting was held May 17, 1930.

The following officers were elected:

J. R. Christie, President.

E. W. Price, Recording Secretary.

W. H. Wright, Corresponding Secretary.

Dr. Schwartz called the Society's attention to the death of Howard Crawley in Philadelphia on May 27, 1929. Mr. Crawley was a charter member of the Helminthological Society and during his residence in Washington he was a frequent contributor to its proceedings.

Mr. Crawley was born in Philadelphia, June 4, 1869. He was educated in the University of Pennsylvania (B.S., 1897) and in Harvard University (M.S., 1901). He was an assistant in the department of zoology at Harvard University from 1900 to 1901. In 1908 he was appointed expert in protozoology in the Bureau of Animal Industry, U. S. Department of Agriculture, in Washington, D. C., and served in various capacities as an investigator in protozoology until 1919. Following his resignation from the U. S. Bureau of Animal Industry, he was appointed parasitologist in the Pennsylvania Bureau of Animal Industry in Philadelphia, where he remained until a short time before his death.

Mr. Crawley's contributions to parasitology were largely in the field of protozoology. His principal contributions to this field were as follows: Studies on the movements of gregarines; descriptions of new species of Sarcocystis; life history studies on *Sarcocystis muris;* dicovery of the occurrence of non-pathogenic tryanosomes in American cattle; systematic position of Sarcosporidia. During the last few years of his scientific activities Mr. Crawley was engaged in studies on size variation of helminth ova as a basis for diagnosis of specific helminthiasis in domesticated animals and poultry.

The Helminthological Society of Washington deplores his untimely death at the age of 59 and extends its sympathy to the members of his family.

Dr. W. H. Wright reported the finding of *Hepaticola sp.* in the livers of three out of 216 dogs examined post-mortem during the past 18 months in connection with antihelmintic investigations. Lesions containing these worms appear as white to yellowish-white filiform areas on the surface of the liver. Press preparations showed the characteristic lemon-shaped ova of Hepaticola with fragments of degenerated worms. Eggs were secured from the liver and cultured by Dr. E. B. Cram, some in tap water and others in a 1 per cent solution of formalin. Those cultured in formalin did not develop. Eggs cultured in tap water on March 1, 1929, showed complete embryonic development on May 6, 1929, and were fed on May 6 and 13, to a 5-months old collie pup. This dog

was killed on July 5, 1929, and 44 separate foci of infestation with the parasite were found on the surface of the liver. Some of the parasites had degenerated, the eggs resting in the stroma of the liver. However, it was possible to dissect out fragments of a female and a male worm. The fragment of the male was about 11 mm. in length. The posterior extremity of the male is provided with a membranous sheath but no spicule is present. The male is 23.5μ thick at the posterior extremity. Length of sheath, 180μ; width of sheath at body terminus, 16.8μ; width of sheath at its posterior extremity, 33.5μ.

Eggs from a second dog which were cultured in tap water on April 30, 1929, showed a state of cleavage on June 10, 1929, but did not become fully embryonated until July 5, 1929. In order to determine whether the parasite would develop in rats, embryonated eggs were fed to two white rats on July 10 and 17, 1929. Two other rats were used as controls. One control died from undetermined causes on July 19; no specimens of Hepaticola were found in the liver.

One of the infected rats was killed on Aug. 10, 1929, but no parasites were found in the liver. At the termination of the experiment on Sept. 20, 1929, the second control rat showed no evidence of infestation. Unfortunately, at this time it was found that the second infected rat had at some time or other escaped from the cage and had disappeared.

A measurement of 15 eggs taken at random from the liver of the dog showed a length of 53 to 59μ with a width of 30 to 32μ. The average length was 57μ; the average width 30.4μ. Nishgori states that *H. hepatica* easily infects the dog and develops to the mature form. While it is possible that the species represented here is *H. hepatica,* the failure to infect the one rat examined and the successful infection of a dog leaves the specific determination in doubt. Lacking a satisfactory description of *H. hepatica,* it seems advisable not to assign this Hepaticola from the dog to a known or new species at this time. Hall states that eggs from a worm possibly belonging to *H. hepatica* were reported by Perroncito (1878) from the liver of a dog. Itagaki, in an undated publication in Japanese, received in the Zoological Division on June 1, 1929, reports the finding of eggs of *H. hepatica* in 8 per cent of 65 dogs in Tokyo. The present report is apparently the first from the United States.

Dr. R. Wetzel reported that the fourth stage larvae of *Oxyuris equi* (Schrank) in freshly opened intestines are found attached to the mucosa of the ventral colon, a fact which, as far as he is aware, has not yet been reported. The larvae attach by drawing a portion of the mucous membrane into the anterior part of the esophagus (the corpus pharyngis according to nomenclature of Martini), which, it is interesting to note, for this purpose has adapted itself to the shape and function of a mouth capsule; the anterior part of the esophagus is structurally a pharynx, but physiologically it is a buccal capsule, with the shape, the position and function of a buccal capsule. Sections show further that the larvae are actually feeding from the mucosa, cells of which can be clearly seen in the lumen of the bulb and intestine, where they are partly digested. The blood red color of individual larvae indicates that occasionally interglandular capillaries of the mucosa are opened by the powerful suction. The mucosa in the neighborhood of the parasites shows eosinophile infiltration.

J. R. Christie reported *Sphaerularia bombi* from Falls Church, Virginia, U. S. A., taken from the body cavity of a bumble bee (*Bombus sp.*). A specimen of this parasite was exhibited.

Dr. G. Dikmans reported that among some nematodes from cattle sent to the Zoological Division from Jeanerette, Louisiana, by Dr. C. W. Rees, there was found a male specimen of *Trichostrongylus delicatus.* This nematode has previously been reported by Hall as a parasite of *Sciurus alberti mimus* from Colorado.

Dr. E. B. Cram presented the following notes: (1) New host records for *Strongyloides avium.*—Natural infestations of this nematode have been found in two wild birds, namely, in the junco (*Junco hyemalis hyemalis*), originating from near Richmond, Virginia; and in the coot (*Fulica americana*), originating from North Carolina. The nematodes were located in the ceca of the junco and in

the lower part of the small intestine, as well as the ceca, of the coot. The possibility that such wild birds as these are responsible for the introduction of this parasite to domestic birds consequently suggests itself. In addition, an experimental infestation has been produced in the ceca of the ruffed grouse (*Bonasa umbellus*) at Beltsville, Md., the culture of eggs of *S. avium* which was fed to the grouse having originated from the chicken. These new records make a total of five hosts for this parasite, the chicken and the bobwhite quail having been reported earlier.

(2) Aberrant larvae of *Physocephalus sexalatus* in birds.—In the loggerhead shrike (*Lanius ludovicianus*), the screech owl (*Otus asio asio*) and the red tailed hawk (*Buteo borealis borealis*) of northern Florida and southern Georgia, and in the wood thrush (*Hylocichla mustelina*) of Viriginia, there have been found aberrant third-stage larvae of *Physocephalus sexalatus* encysted in considerable numbers in the intestinal wall and in the mesenteries on the outside of that wall. The birds apparently became infected as a result of eating dung beetles which serve as intermediate hosts of this stomach worm of swine. Since such aberrant larvae are thus prevented from reaching their final hosts, it is possible that birds may play a considerable part in limiting the numbers of these nematodes occurring in swine.

(3) Gapeworm disease of birds in Alaska.—A. H. Twitchell of Moore Creek Flat, Alaska, has on several occasions submitted for examination birds which had been noted by him to be suffering from gapeworm disease. The birds have included the Gambel sparrow (*Zonotrichia gambelii*), the water-thrush (*Sciurus noveboracensis*—subspecies [?]) and the junco (*Junco hyemalis*—subspecies [?]), as identified by A. H. Howell of the Bureau of Biological Survey. The gapeworms from the trachea in each case have been identified as *Syngamus trachea;* they are smaller in size than specimens of *S. trachea* from the chicken and turkey but this difference is not significant in view of the size difference in the bird hosts. As regards the possibility of a transfer of the gapeworms from these wild birds to domestic fowls, or vice versa, Mr. Twitchell states that he has observed sparrows and other birds to be suffering from gapes in three different places, all of these places being in wild country with no chickens or turkeys in the vicinity. On the other hand, numerous inquiries in towns in that part of Alaska have failed to bring to light any authentic cases of gapes in chickens. These findings suggest that, whereas emphasis is rightly placed on the turkey as an important factor in the spread of gapeworms to chickens, since turkeys are so closely associated with chickens, on the other hand there may be numerous wild birds of North America which harbored this parasite before its spread to domestic fowls.

(4) "Poultry ascarid" as a common name for *Ascaridia lineata*.—It is suggested that since *A. lineata* is in the family Ascaridae and has the general appearance of an ascarid, it would be preferable to apply the term "poultry ascarid" in general discussions rather than the long and complicated common names, such as "large roundworm of intestines" or "intestinal large roundworm of poultry," which are in use at present.

Dr. H. E. Ewing reported as follows: Dr. W. A. Hoffman, of the School of Tropical Medicine of the University of Porto Rico, has recently found the dog-kangaroo louse, *Heterodoxus longitarsus* (Piaget), in Porto Rico. He has sent specimens to the writer for confirmation of his identification and has asked that a note of this finding be presented to the Helminthological Society of Washington. He states:

"This, I presume, constitutes the first record for this form from Porto Rico. They occurred upon several dogs from Rio Piedras, a city a few miles from San Juan. So abundant were these lice that by rubbing one's hand over the rump of an infected animal, hundreds were deposited upon paper placed beneath."

The dog-kangaroo louse is of particular interest to parasitologists because its recent maneuvers have done such violence to our ideas of host specificity. For some countless centuries, presumably, this louse lived in perfect contentment

upon kangaroos in the continent of Australia. Then, following the importation and exhibition of these picturesque marsupials in our own and other countries, the louse broke out in many places as an important parasite of dogs. Today it occurs on domestic canines over much of temperate and tropical America.

Dr. M. C. Hall presented a short note on the durability of certain parasite structures as shown by a slide showing eggs of *Multiceps multiceps* which had been air dried for over 7 years and 7 months, and which when mounted showed the shell and in many cases the hooks of the onchosphere in a good state of preservation. He called attention to our one fossil nematode and expressed the opinion that there was still some likelihood that we might obtain fossils of the parasite worms.

Miss Myrna F. Jones reported the ground beetle, *Calathus opaculus,* as an additional intermediate host for the poultry cestode *Raillietina cesticillus.* A specimen of *Calathus opaculus* was fed gravid segments of *R. cesticillus* and after 28 days contained fully developed cysticercoids of this species. The material was fed to a chick and after 26 days gravid segments of *R. cesticillus* were passed in its droppings. Control chicks were negative.

Dr. E. W. Price presented the following notes: (1) The occurrence of *Soboliphyme baturini* Petrov in North America.—Four specimens of a peculiar nematode were forwarded to the Bureau of Animal Industry for identification during the winter of 1928, from Helena, Mont., the worms having been collected from the stomach of a wolverine (*Gulo* sp.). These worms have been determined as *Soboliphyme baturini,* a nematode recently described by Petrov (Zool. Anz., 86, 1930) from specimens collected from *Martes zibellina, Vulpes vulpes,* and *Felis catus domesticus* from Kamchatka and Siberia. This note constitutes a new host and distributional record for this species.

(2) Cysticercoids in the mesenteric lymph glands of white mice.—Armed cysticercoids were recently found in the mesenteric lymph glands of about one-third of the white mice examined in the Zoological Division. These cysticercoids appear to be those of *Hymenolepis nana.* All mice examined harbored adult tapeworms of this species and the possibility that these larvae might have been those of another species is exceedingly remote.

Dr. Benjamin Schwartz presented the following summary of a report on oesophagostomiasis in pigs submitted by Dr. E. W. Nighbert: A herd of 73 pigs raised under the swine sanitation system failed to thrive despite favorable conditions as regards feed, pasture, housing, etc. Frequent examinations of the feces failed to reveal worm eggs in sufficient numbers to account for this condition as one produced by parasites. The owner sacrificed 3 or 4 pigs and post-mortem examination showed an extensive infestation with nodular worms. The large intestine contained, moreover, numerous nodules, some of which were ulcerated. The mucous membrane of the large intestine showed congestion.

Examination of the worms present in the lumen of the intestine showed them to be largely immature which would account for the relatively small number of eggs in the feces. The original owner sold the pigs and their further fate could not be followed. However, the new owner has had little luck in fattening them despite a good supply of feed.

Dr. D. F. Sinitsin presented the following contribution to the life history of the salmon-poisoning fluke of dogs, *Nanophyetus salmincola* (Chapin): The cercaria of *N. salmincola* develops in *Goniobasis plicifera silicula,* one of the most common snails of the running waters of Oregon, and it belongs with the group of so-called stump-tailed cercariae. The parthenogenetic generation of *N. salmincola* is composed of redia-shaped parthenitae, which are furnished with a well developed pharynx, an intestine reaching the posterior end of the body, and a birth opening; the pedal appendages are absent. The largest rediae are about 1.4 mm. long, and they produce rediae and cercariae simultaneously. The cercaria is about 0.27 mm. long and 0.08 mm. wide, the body being very contractile. The oral sucker, about 0.05 mm. in diameter, is a little larger than the acetabulum, the latter being located about the middle of the body. The cercaria is provided

with a simple stylet, about 13μ long, and has six unicellar glands on each side. A pharynx, 0.02 mm. in diameter, immediately follows the oral sucker. The intestine bifurcates about half way between the suckers, and the ceca extend to the level of the posterior border of the acetabulum. The excretory bladder, enlarged anteriorly, gives off two short lateral branches which are divided into an anterior and a posterior vessel. The tail is conical when viewed from the side, its tip being bent in a dorsal direction; its ventral surface is provided with a series of minute grooves, the partitions separating these grooves terminating at the flattened posterior end in a row of hairlike projections. On the ventral side, behind the acetabulum, there is an elongated slit made up of lateral folds of the skin. The slit leads to a cavity, the thick walls of which are formed of four very large cells which secrete a viscous substance. It is an adhesive organ by means of which cercariae stick to their victims. The genital primordia are well developed, and consist of two testes situated laterally and opposite each other in the posterior part of the body, an ovary at the right side and posterior to the acetabulum, and a uterus, together with the male copulatory apparatus, behind the acetabulum.

The cercariae do not progress while in the water, the only movement being a rhythmical contraction of their bodies. When they come in contact with a suitable host, a salmon or trout, they become very active and crawl about energetically. Now and then they try to bore into the skin of the fish. Eventually they succeed in penetrating and become encysted somewhere under the skin, but most of them, naturally, attach themselves to the belly of the fish, move along it, reach the urinary aperture, go through it, and eventually reach the kidney. The entire process, through encystment, requires about two to three hours.

Feeding experiments have shown that guinea-pigs are susceptible to infestation, but in spite of having thousands of worms in their intestine, they show no signs of being sick. However, the infestation in guinea-pigs is of short duration, all worms being eliminated by the twelfth day, and they are subsequently immune to infection. White rats were not susceptible to infection. Natural hosts of *N. salmincola* are to be looked for among the carnivores that feed on raw fish, and a number of these have already been found to carry the fluke.

Dr. G. Steiner reported the presence of *Tylenchus dipsaci* in sweet potatoes grown in New Jersey. This host is new. Infested sweet potato tubers were exhibited. The infection first breaks out under the skin, producing there a black layer whereas the interior of the potato remains first whitish. Later, however, the infestation proceeds also to the interior of the tuber, turning it black. The form of *Tylenchus dipsaci* found in this new host is the same as found in narcissus, phlox and other hosts; this form may be called *Tylenchus dipsaci* var. *communis.* It differs from the type in that it has spicula which are shorter and a bursa which reaches only halfway down the tail contrary to the type in which it goes close to the tail end. The form from the teasel has to be considered the type.

Another form of *Tylenchus dipsaci* was recently brought to Dr. Steiner's attention by Mr. C. E. Scott, California State Department of Agriculture. It is a *Tylenchus dipsaci* living in *Amsinckia intermedia,* a native plant of California belonging to the family Borraginacae. The flower heads of this host were transformed into galls which contain millions of the nema. This form of *Tylenchus dipsaci* also differs from the type in being thicker, in having the vulva more posteriad and in being viviparous. The name *Tylenchus dipsaci* var. *amsinckiae* is therefore proposed.

Dr. Steiner further exhibited drawings of a marine nema (Steineria sp.) with a greatly thickened cuticle; in fact, the cuticle reaches almost two-fifths of the body diameter. This greatly thickened exoskeleton is segmented, each individual segment forming a thick annule which connects with the anterior and posterior one by highly developed articulations, along eight longitudinal ridges protruding outward. Nothing is known about the behaviour, life cycle and habits of this marine form which would throw light upon the significance of this thickened exoskeleton.

J. R. Christie, Secretary.

BOOK REVIEWS

Tratado De Parasitologia Vol. IV Arthropodes Parasitos e Transmissores De Doencas. By Dr. Cesar Pinto. 845 pp., 356 figs. and 8 plates.

In this work which constitutes the fourth of a series entitled a treatise on parasitology in the Bibliotheca Scientifica Braziliera, are handled the parasitic arthropods and their relations to disease transmission. The author who is on the staff of the famous Instituto Oswaldo Cruz is well known for his work in this field and has handled his topic in complete and masterful fashion. The work has been issued in two parts or volumes, and makes an impressive appearance. These two parts contain together 845 pages of text with eight full plates and 356 text figures. The first part begins with an extended list of the major works on parasitology in all languages. The author then takes up in individual chapters the Ixodidae, Trombdiidae, Gamasidae, Sarcoptidae, Demodecidae, Anoplura, Mallophaga, Triatomidae, Cimicidae and Siphonaptera in the first part. The second part treats in successive chapters the Tabanidae, Muscidae, Sarcophagidae, Oestridae, Simuliidae, Ceratopogoninae, Phlebotominae and Culicidae. In each case the text covers the structure, life history, classification, biology, distribution, and method for preventing or limiting the ravages of individual species. After these topics come a chapter on the Rickettsias and their hosts, a glossary of technical terms and a splendid index to terminate the work. Each chapter has its own bibliography which includes representative publications from all sources and is not limited as often in such books to the work of a single country or group of investigators. The text is abundantly illustrated and the figures are new and well chosen. By virtue of its climate and other conditions Brazil has as is well known many important problems in dealing with insect transmitted diseases. This work will be of inestimable value for all persons working there on these questions and constitutes also a welcome source of information to those at a distance who are called upon to handle these matters from various points of view. The author is to be congratulated on his comprehensive handling of the material. The work is a tribute to scholarship and research in Brazil of which the author and his colleagues may well be proud.

Fauna of British India. Cestoda. Vol. I. By T. Southwell, Lecturer in Helminthology, Liverpool School of Tropical Medicine. 385 pp., 221 figs.

The appearance of this book as one of a series dealing with the fauna of a special region masks to a degree its true character for it is much more than a taxonomic study of a regional fauna. The long residence of the author in India as Director of Fisheries and his extended studies on the Cestoda as evidenced by numerous publications in this field fitted him peculiarly to make a finished contribution. Within the limits set by the title the book is in fact a monograph on the Cestoda and will be of service not only to those working on material from the region indicated but to general students of the group as well. An extensive bibliography opens the text and is followed by a systematic index and a comprehensive introduction including the history of the Cestoda, their general structure and biological relations with notes on methods of study. The taxonomic section which embraces the major portion of the book handles in order each family, genus and species. One is surprised to note that such a large part of the order is included from a region which has been studied only for a brief time and by so few workers. The author's treatment of his material is balanced, his judgment on controversial questions fair and his presentation clear. The book is well printed and illustrated by numerous original and well selected figures. Citations are complete and accurate, and typographical errors rare so far as ascertained by a first reading. The citation of Leidy's work under the date of 1904 when it was reprinted, introduces unfortunate misinterpretations among workers not familiar with the situation and is moreover unnecessary since the exact date and location of each original are given in the reprint. A larger index

would also be useful at times. But such items are very minor criticisms. The work is well done and the book will be welcomed by all and found widely useful.

Acta Leidensia Edita Cura et Sumptibus Scholae Medicinae Tropicae. Volume IV, 212 pp.

The present volume maintains the scholarly standard set by earlier members which have been reviewed in the Journal. The first article is a description of the new hospital on the waterfront at Rotterdam which is devoted to the clinical work of the Institute of Tropical Medicine. The other articles embrace the results of investigations on the scientific problems on which the staff of the Institute is working. These include among others studies on filariasis, hookworm anemia, biology of Anopheles, amoebic dysentery and malaria.

Trematoda. By Otto Fuhrmann, Neuchâtel. In Handbuch der Zoologie by Willy Kükenthal. 140 pages, 175 figures.

The attention of parasitologists should be directed to this recent publication which because it constitutes only a section of a comprehensive handbook may escape the notice of some workers. Professor Fuhrmann has given a most satisfactory account of the flukes, the first which has been published in some twenty years. The structures, life history and taxonomy of the group and its various subdivisions is fully discussed. The text is thoroughly up to date and well written. The investigator will find in this article the morphological data needed for a fundamental understanding of the Trematoda.

Fifteenth Annual Report of the Director of Veterinary Services. Department of Agriculture, Onderstepoort, Pretoria. 1209 pp. The Government Printer, Pretoria, South Africa.

The Fifteenth Annual Report of the Director of Veterinary Services, Union of South Africa has just appeared from Pretoria in two volumes covering 1209 pages with many tables, figures and full page plates. Two sections, on protozoal diseases and on parasitology call for especial mention here. Trypanosomes, piroplasmas, several interesting nematodes, the life history of Moniezia and studies on a new schistosome from sheep are among the items handled. In both appearance and contents the volume reflects great credit on the department.

The investigator in Parasitology is so inseparably bound to his apparatus and the methods for its efficient utilization that he will be interested in a new book by John Belling, Cytologist of the Carnegie Institution of Washington, entitled *The Use of the Microscope*. The work is at once complete and concise. The text is clearly written and contains as one very valuable feature a synopsis of the causes of injury to the microscopical image which will be most helpful to beginners. This book is reasonably well illustrated though not so much so as most other works in this field. The chapter devoted to A Hundred Microscopical Objects of Biological Interest leans unnecessarily towards the botanical and genetic side of microscopical study. References to parasitology are both few and brief. The long list of references to literature will prove bewildering to the student except as it may be analyzed by some teacher thoroughly familiar with this field.

This spring Professor F. Zschokke, the well known parasitologist of Basel, Switzerland, celebrated his seventieth birthday and also the completion of forty years of University work. In commemoration of the event the Verlag Helbing and Lichtenhahn in Basel has issued an attractive booklet *Vivat Academia* by Professor Zschokke, dedicated to his students. It is illustrated by a splendid photograph of the author at work in his laboratory and a series of views of his journeys with a vivid and interesting story of his experiences. The Journal joins with students and friends in extending congratulations and good wishes to Professor Zschokke.